REPORT

OF THE

Commissioner of Agriculture.

1888.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1889.

[PUBLIC RESOLUTION—No. 48.]

Joint resolution to print the Agricultural Report for eighteen hundred and eighty-eight.

Resolved by the Senate and House of Representatives of the United States of America in Congress assembled, That there be printed four hundred thousand copies of the Annual Report of the Commissioner of Agriculture for the year eighteen hundred and eighty-eight; seventy thousand copies for the use of the members of the Senate, three hundred thousand copies for the use of the members of the House of Representatives, and thirty thousand copies for the use of the Department of Agriculture, the illustrations for the same to be executed under the supervision of the Public Printer, in accordance with directions of the Joint Committee on Printing, said illustrations to be subject to the approval of the Commissioner of Agriculture; and the copy for the illustrations of said report shall be placed in the hands of the Public Printer not later than the twentieth day of December, eighteen hundred and eighty-eight, and the copy of the text not later than the first day of February, eighteen hundred and eighty-nine.

SEC. 2. That the sum of two hundred thousand dollars, or so much thereof as may be necessary, is hereby appropriated, out of any money in the Treasury not otherwise appropriated, to defray the cost of printing said report.

Approved, October 20, 1888.

440

TABLE OF CONTENTS.

LIST OF ILLUSTRATIONS.

REPORT

OF

THE COMMISSIONER OF AGRICULTURE.

U. S. DEPARTMENT OF AGRICULTURE,
COMMISSIONER'S OFFICE,
Washington, D. C., December 1st, 1888.

To the PRESIDENT:

I respectfully submit my fourth annual report as Commissioner of Agriculture.

Seed-time and harvest have recorded again the intentions and fruitions of the agricultural year. A season of abundant if not excessive moisture, as the previous one was of deficient rain-fall and consuming heat, it has still been fruitful in a high degree. The soil has doubtless yielded its wealth the more generously from the fertilization drawn from its depth by the drought of the previous summer. Though the winter's severity touched the wheat crop injuriously, the summer's favors came near to full reparation for the injury, while the spring-sown grain was less fortunate in its history. There is such variety of soil, climate, and product in our broad domain that a blight in one section is a blessing in another; and in the same district a drought that parches the uplands may dry the bottoms, while rains that fertilize the hills may flood the valleys. Thus compensations repair disasters, unless caused by want of thrift or lack of industry in the cultivator. A famine, the reality that affrights so many countries, is a phantom in this of which the people have no present fear.

The Department has continued its efforts to apply the latest results of scientific discovery to agricultural practice. Its aim is ever practical, in the direction of economy and variety in production, through the union of science and experiment and the advance of rural education.

I am pleased to record that the past year has been one of much greater activity in the Department than it has ever before experienced. The work of the new sections and branches organized in the

Department will prove of great value to the future agricultural operations of this country. The investigations made have excited popular interest, and the results obtained have not only been helpful to the farming class, but some of them are significant in that they, in a measure, anticipate the still further development of the wonderful agricultural resources of the United States.

AGRICULTURAL EXPERIMENT STATIONS.

The appropriation of $15,000 per annum to each of the States and Territories which have established agricultural colleges or agricultural departments of colleges, in accordance with the act of Congress approved March 2, 1887, has led, according to the latest accounts at hand, to the establishment of new stations, or the increased development of stations previously established under State authority, in thirty-seven States and one Territory. In several States two or more distinct stations are in operation; in others the stations have several branches under one management. Counting these latter as single stations the total number at present is forty-two, but counting the branch stations separately the total number would not be far from fifty.

The first agricultural experiment station in the United States was established in Connecticut in the year 1875. The example was followed elsewhere until, in 1886, some seventeen of these institutions had been organized in as many States. This rapid growth of an enterprise for elevating agriculture by the aid of science, its espousal by the United States Government, its development to its present dimensions in the short period of fourteen years, and, finally, the favor with which it is received by the public at large, are a striking illustration of the appreciation on the part of the American people of the wisdom and the usefulness of calling the highest science to the aid of the arts and industries of life.

This enterprise in the United States is indeed only a part of a more general movement. In Europe experiment stations have been a prominent feature of agricultural progress during nearly forty years, and with constantly increasing number and effectiveness. At the moment that this is being written a request comes to the Department for documents pertaining to agriculture in the United States for the use of persons engaged in establishing experimental farms in a province in India still under the control of a native independent prince, who is using this instrumentality for the elevation of the agriculture of his country.

Most of the new stations are in actual operation. Bulletins and reports have been published giving accounts of their organization and experimental and other work. The investigations cover a very wide range of topics of interest to the farmer. The stations have in nearly all cases manifested their wisdom in entering upon inquiries

especially adapted to the localities in which they are situated, without neglecting subjects of more general interest.

The present is an auspicious time for this undertaking. In the history of no nation before have there been such a thirst for knowledge on the part of the great masses of the people, such high and just appreciation of its value, and such wide-reaching, successful, and popular schemes for self-education; never before has the great agricultural public been so willing and indeed so anxious to receive with respect and use with intelligence the information which science offers; never before has science had so much to give. The prospects then for this, the largest scientific enterprise in behalf of agriculture that any government has undertaken, are full of promise, notwithstanding some manifest dangers which lie in the way of its progress.

These dangers are those due to the crudeness of such enterprises in their early stages, to the lack of experience, and to political and other complications. Crudeness will pass away and experience will come. The greatest danger, that of political interference and manipulation, needs to be carefully guarded against. Whenever it is understood that anything but special fitness constitutes qualification for positions in the management or work of these institutions, deterioration in the workers and the work is sure.

On the other hand, there is great cause for encouragement in the evident sincerity and earnestness of purpose with which the officers of the stations are in almost all cases performing their duties; in the character of the educational institutions in whose charge the stations have been placed; in the earnest watchfulness and hearty sympathy of the farmers of the country; in the interest and co-operation of the greatest authorities in science; and, finally, in the action of Congress by which provision is made for Government regulation and aid.

In order to carry into effect the provisions of the act of March 2, 1887, by which the experiment stations are established, and of acts supplementary thereto, the act approved July 18, 1888, entitled "An act making an appropriation for the Department of Agriculture for the fiscal year ending June 30, 1889, and for other purposes," appropriates:

Five hundred and ninety-five thousand dollars; ten thousand dollars of which sum shall be payable upon the order of the Commissioner of Agriculture to enable him to carry out the provisions of section three of said act of March second, eighteen hundred and eighty-seven, and to compare, edit, and publish such of the results of the experiments made under section two of said act by said experiment stations as he may deem necessary; and for these purposes the Commissioner of Agriculture is authorized to employ such assistants, clerks, and other persons as he may deem necessary.

Section 3 of the act of March 2, 1887, provides:

That in order to secure, as far as practicable, uniformity of methods and results in the work of said stations, it shall be the duty of the United States Commissioner of Agriculture to furnish forms, as far as practicable, for the tabulation of results

of investigation or experiments; to indicate, from time to time, such lines of inquiry as to him shall seem most important; and, in general, to furnish such advice and assistance as will best promote the purposes of this act. It shall be the duty of each said station, annually, on or before the first day of February, to make to the governor of the State or Territory in which it is located a full and detailed report of its operations, including a statement of receipts and expenditures, a copy of which report shall be sent to each of said stations, to the said Commissioner of Agriculture, and to the Secretary of the Treasury of the United States.

While, in accordance with its duty in the disposition of public funds, the Government reserves the right to regulate the research which it endows, and while this regulating power is expressed in the same legislation by which the stations themselves are established, it should in my opinion be exercised mainly in the form of wise and sympathetic help.

The Department of Agriculture can aid the experiment stations in their relations to each other, in their use of the results of experimental research, and in their connection with the agricultural public. To be first among the stations the Department should be the servant of them all. It should exercise not dictatorship, but leadership. Its influence should be powerful in bringing the stations together in co-ordinating their work; in making the fruits of other research and experience, past and present, at home and abroad, available to them; in prosecuting lines of pioneer research which will in a measure relieve the stations of a difficult but necessary task, and enable them to apply their energies more fully and successfully to the study of the questions which bear directly upon the practice of agriculture; in collating, condensing, and distributing their results, and in helping to carry the practical outcome to the farmer in a form in which he will appreciate and use it.

To carry out this work I have instituted an office of experiment stations as a special branch of this Department and appointed a director at its head. The organization and functions of this office will naturally shape themselves to the needs of the enterprise as they arise.

The most immediately pressing need seems to be that of a clearing-house and an exchange for the stations. The stations are widely separated; they need to know more about each other's work; they need each other's help, especially that which comes from the interchange of experience. Much is gained by the proper distribution of work and by co-operation where that is feasible. As a clearing-house this office can facilitate intercommunication beween the stations, collate the results of their work, and facilitate its most advantageous co-ordination. It can serve as an exchange or distributing point for information in two ways, negotiating between the stations and the agricultural public on the one side and between the stations and the world of science on the other.

One of the means by which this Department can mediate between

the stations and the agricultural public is the issuing of a series of farmers' bulletins, which should collate the results of station work bearing upon special topics, and the teachings of other research, and put the whole into a form so plain that the intelligent farmer will understand it, so brief that he will read it through, and so practical that he will take it to heart. Thus while each station is distributing its own results to the farmer of its own State, this instrumentality will help to make the several stations serviceable to the agriculture of the whole country.

As a mediator between the stations and the world of science, this branch of the Department should be in a condition to collate the results of experimental research in this country and in Europe, and publish them in convenient form for the use of the station workers and others interested in the science of agriculture. The past forty years has been a period of great and increasing activity in agricultural inquiry, especially in Europe. The mass of material accumulated is large and rapidly growing; it is mostly in foreign languages, and in costly journals, publications of learned societies, monographs, and other books, which but few of our workers have, and which, with lack of leisure, but few could sufficiently utilize if they had them. Indexes of literature of given subjects and, especially, abstracts of experimental research are wanted.

One need is a journal for the stations, to contain accounts of their current research, abstracts of similar work in this and in other countries, and other matters of mutual interest. What is wanted is a publication, properly edited, adapted to our special conditions, appearing regularly and giving the latest information, doing for workers in these lines what *Die Landwirthschaftlichen Versuchs-Stationen*, the *Central-Blatt der Agrikulturchemie*, and other publications do for the German stations; in short, a means to provide prompt and constant intercommunication between the stations and bring them from outside the things they want to know.

Information is also greatly needed in regard to past work and its results. This would be probably best brought to the stations in the form of monographs on special subjects. The object of these would be to show the actual extent to which certain more important subjects have already been investigated, the methods and results of work done, the specific questions which now most need investigation, and the best means and methods of experimenting. The laws that underlie the problems our stations have to work on, and many of the questions themselves, are the same that have been studied for half a century. It is important to avoid going over old ground, to start where others have left off, and with the benefit of their experience. Such instrumentalities to tell our workers what has been done, and indicate what there is to do and how best to do it, and thus help them to utilize work accomplished instead of doing it over again, would

be very useful. For preparing these publications means ought to be provided for securing the services of the ablest specialists in this country and in Europe. All this would cost no little labor, learning, and money, but with the particularly pressing call for every possible assistance of this sort, the expense would bear no comparison to the usefulness; indeed, it is a question whether the stations can afford to be without it.

The well-advised deliberations and action of the American Association of Agricultural Colleges and Experiment Stations were referred to in my last report. It will be observed that the recommendations above made are entirely in accordance with those of the committee on station work of that organization, the report of which was published by this Department last winter, and that the work which the Department has undertaken in connection with the experiment stations has been placed in charge of the chairman of that committee.

In my last annual report I recommended the establishment of a central experiment station in connection with this Department. The work of the stations requires much study of methods of investigation and other pioneer work of research. This is as necessary to successful experimenting as the foundation is to the house. It involves the fullest knowledge of past experience, a great deal of the labor of specially trained experts, and often very costly appliances. This abstract research is very difficult for the individual stations to undertake, and yet the lack of it is one of the serious obstacles to the practical solution of the questions they have to deal with. The act of Congress requires the Commissioner of Agriculture to indicate from time to time such lines of inquiry as to him shall seem most important. To do this properly will require more or less research. Furthermore, there are numerous questions which affect large areas, or the whole country, in which co-operative work will be desirable, but which likewise require preliminary investigation for their proper planning. To relieve the stations of much costly and laborious scientific work and enable them to devote their energy the more completely to the things that are of practical interest to the farmer, and to enable the Department to give the advice and assistance which Congress calls for and the stations need, would be proper functions of a central station. If properly arranged it would also serve as a useful model and as a means of explaining to people interested in such matters, agriculturists, educators, men of science, legislators, and others who flock to Washington from all sections of the country, and from other parts of the world as well, what an experiment station is and how its work is most successfully accomplished.

The branch of the Department which connects it with the experiment stations should, I believe, develop such an institution. This would in no way take the place or do the work of the stations throughout the country, but would, on the other hand, be a most

helpful, economical, and, I am inclined to add, essential part of the whole organization. Its need has already been felt and expressed by stations which have had the largest experience. Its growth should be gradual, its character and organization should be shaped by exigencies as they arise, but I believe that, in some form or other, it should be provided for in the near future.

While the experiment stations are primarily for the benefit of agriculture, and through it for that of other national interests, their support comes as directly from the rest of the people as from the farmers. The chief agricultural product is food, which all need. More than half of the earnings of the working people in this country, as in Europe, are and inevitably must be spent for food, and yet even the most intelligent know less about the relation existing between the nutritive value and the cost of their food than about the value as compared with the cost of their clothing, houses, fuel, or any of the other necessaries of life. This lack of popular understanding of the pecuniary economy of food, and of its physiological economy as well, results in great loss of money and injury to health. For improvement the first requisite is information, that which comes only from research. Such research might be appropriately begun by this Department and, when the lines are well defined, advantageously carried out by the stations. The results of such inquiry would also have a most immediate and practical bearing upon the exclusively agricultural interests of the country, especially in the portions devoted to meat production. Investigation has already been carried far enough to indicate that the laboring classes in Europe are underfed, and that what they most lack to give them the bodily strength and vigor which characterize our own working people is the nutriment which is supplied in the most concentrated form in the meats, including pork, which we produce in such large excess. One way to secure the removal of the onerous restrictions imposed by the governments of Europe upon the importation of American meats is to demonstrate the great disadvantage accruing to the masses of the people from these restrictions.

I venture to suggest that inquiries in these directions are appropriate for this Department and for the experiment stations as well; that the initiative may properly be taken by the Department, and, when the lines are well defined by preliminary investigation, such stations as are in condition to do so may prosecute them with advantage. A small appropriation would do a most useful work.

Thus far, of course, the work of the Department in connection with the stations is merely begun. In accordance with the policy of the Department to ally itself as closely as possible with these institutions, personal visits have been made to as many of the stations as time has permitted. A directory of stations and station officers and a catalogue of publications are in preparation, and are to be followed by

indexes of literature, and so much of the work above indicated as the demands of the future may require and the means provided allow. To carry out this part of the work of the Department for the next fiscal year I have asked for $15,000, believing it to be wise to make the request a moderate one, and smaller rather than larger than the demands would seem to justify. This sum will suffice only for the beginning of the large amount of work that is pressingly needed. I have refrained from making any estimate of the whole amount which will be necessary to carry on the national stations during the next year, and for which an appropriation of $595,000 was made by Congress for the current fiscal year, deeming it advisable to await the development in station organization.

The path to success in this experiment-station enterprise passes by the fountains of abstract science and by the farms and firesides of the American people. If the Department is to do its share of this great work it must be by unifying the efforts of the stations, by bringing the best science of the world to their aid, and by carrying their best products "not down to the farmer, but home to the farmer," whom they serve. For this it must have generous support. A great ship needs costly steering apparatus. Parsimony here is the worst possible economy. I trust that in due time means will be provided to enable the Department to secure, retain, and develop to their highest efficiency the ablest men in the different lines of work and to insure all needed means for meeting the demand imposed upon it by so great an undertaking. If this call is for something greater than has ever elsewhere been done it is because of the magnitude of the experiment-station enterprise, the urgency of the demand, and the wisdom of generous supply.

I append herewith a synopsis of the work performed by the several divisions of the Department.

BUREAU OF ANIMAL INDUSTRY.

The work for the eradication of contagious pleuro-pneumonia has been the most important of the duties devolving upon this Bureau during the year. The beginning of this work, less than four years ago, was under circumstances which were anything but encouraging. The plague had been permitted to propagate itself in the Middle Atlantic States practically undisturbed for more than a quarter of a century. The dairies about some of our largest cities were hot-beds of contagion. The stock-yards of these cities had become infected and the disease was spread continually by calves and stock cattle going from these yards into country districts. Even the West was invaded and the great stock-producing States of Illinois, Missouri, and Kentucky were suffering from the prevalence of this malady.

To meet this alarming condition we had an imperfect national law, an insufficient appropriation, and little, if any, provision for co-op-

eration on the part of the States. The law establishing the Bureau was, however, soon supplemented by temporary legislation in the appropriation bills, the amount appropriated was increased sufficiently to meet the emergency, and State co-operation has been secured in those States where the contagion existed. With the authority obtained in this manner, it was possible to undertake vigorous measures for the extermination of the plague.

At the time the previous report was submitted the Western States had been about relieved from the presence of this malady. A force was still stationed at Chicago, however, and cases in the chronic stage were occasionally being found. With rigid supervision of the trade and the slaughter of all cattle in the infected district, the last traces soon disappeared, and on April 1 it was deemed safe to remove all quarantine restrictions and withdraw the force that had been operating there.

During this time active measures had been carried on in Maryland, and many affected and exposed cattle had been slaughtered, thereby freeing the country districts from the trouble; but the regulations made under the State laws were not sufficiently stringent for the infected city districts, and the results were not satisfactory. In November, 1887, the State live-stock sanitary board was induced to make an order applying regulations adequate to the conditions in Baltimore County. This involved a large increase of the force stationed there and in the various items of expense which were necessarily incurred, but the rapid progress made under the new plan is a sufficient justification for the change.

There have been slaughtered in Maryland, from January 1 to November 30, 1888, 459 animals affected with pleuro-pneumonia, and 1,036 exposed animals. The result has been to promptly remove all traces of the disease wherever these have been discovered, and to wonderfully lessen the number of cases which have developed. During the month of October but three affected herds were found in the State, and during November but two were found. Unless for some unforeseen reason there is an extension of the disease, the time is not far distant when Maryland will be entirely free from its presence.

A year ago there was some apprehension in regard to the existence of pleuro-pneumonia in Pennsylvania. After considerable correspondence a plan of co-operation was arranged, and in April the city of Philadelphia was placed under quarantine restrictions by the governor's order, and a sufficient force was stationed there by the Bureau of Animal Industry to inspect all cattle within the quarantine limits, and to control the movement of such animals. The enforcement of these measures has shown that the malady did not exist to any great extent in that district. Only 63 affected and 131 exposed animals have been slaughtered, and it is believed the State of Pennsylvania

is now free from the infection. The quarantine will be raised on December 15, but a small force will be left to supervise the interstate commerce in cattle until the neighboring States are found to be safe.

Since my last report a thorough quarantine has been established in Hudson County, N. J., by co-operation with the State board of health. This section of the State has long been known to be harboring the pestilence, but never before were sufficiently stringent regulations enforced to control its ravages or discover all of its hiding-places. As a result of the quarantine, affected herds have been discovered and slaughtered, the stables and stock-yards have been kept disinfected, the incoming cattle have been inspected, and the disease has gradually disappeared. Taking the whole State, there were 19 herds found diseased in September, 14 in October, and only 2 in November. This result is very encouraging, and it is believed that but little more work remains to be done. It has been necessary to slaughter, since January 1, 502 diseased and 945 exposed animals.

In New York the infected district was much larger than in any of the other States and it was anticipated that by far the heaviest work would be found here. The active work was begun in the old infected district of the State about a year ago by placing stringent quarantine restrictions over five counties and inspecting, numbering, and registering all cattle in that district. From January 1 to November 30, 1,576 affected cattle and 3,196 which had been exposed were purchased and slaughtered.

Notwithstanding the fact that a decision of the court made it necessary to obtain additional legislation from the legislature, and also required new proclamations from the governor, the work was pressed forward in spite of all obstacles until the exhaustion of the appropriation in May. This caused a cessation of active work for nearly two months, with only sufficient supervision to hold what had already been gained. Since the last appropriation was made there has been every effort to urge forward the work as rapidly as possible. Two counties, Westchester and Richmond, have recently been declared free from the contagion and the quarantine restrictions removed. Unfortunately a new outbreak has been discovered in Orange County, which will increase the expenses, but which will not delay the period of the final eradication of the plague from the State.

The county of New York has been very nearly freed from this disease, but the continued traffic through this commercial center makes it necessary to enforce quarantine regulations until all other portions of the State have been relieved of it. It will require at least one more year to complete the eradication from the counties on Long Island.

In general it may be said that the amount of work done has been greater than was anticipated, and the results are very gratify-

ing. The following figures, covering all the pleuro-pneumonia districts, show the magnitude of the task which the Bureau has had in hand:

From January 1 to November 30 there were inspected 35,451 herds, containing 304,698 head of cattle. Of these animals 183,257 were tagged with numbers and registered upon the books of the office, and 106,415 were examined more than once.

During the same period 630 herds, containing 8,604 animals, were found affected with the disease, and the Bureau has purchased and slaughtered 2,649 diseased animals and 5,490 that had been exposed. The number of stock-yards, stables, and other premises disinfected reached the number of 1,876. There have also been 41,361 *post-mortem* examinations made, which resulted in finding 3,380 carcasses affected with pleuro-pneumonia.

In addition to the work for the eradication of pleuro-pneumonia, the Bureau has undertaken the control of glanders among horses in the District of Columbia. This work is done under authority of the District Commissioners in accordance with the act of Congress establishing the Bureau. This disease exists to a considerable extent, and from July 1 to December 7, 23 affected horses have been killed.

The investigations of swine diseases have been continued, and have confirmed the results published in the reports of 1887, and, in addition, have brought out more clearly the characteristics of the disease and the measures necessary for its prevention. There is no longer any doubt that the epizootics among swine may be divided into two very distinct diseases; that both of these are widely disseminated and cause very serious losses. Bulletins are now in preparation in which a systematic account will be given of all the important facts connected with the origin, cause, and nature of these diseases, and the methods to be adopted for their prevention and treatment.

An investigation of the sheep and wool industry has just been completed, and a report is now in preparation which is expected to place this subject clearly before those interested in this branch of agriculture. Much important information has been gathered which, it is believed, will have a good influence on sheep husbandry in general, and will enable those engaged in it to see and correct the mistakes which have heretofore been made. It is our aim to present those methods which have been found successful and profitable, in order that they may be adopted by others who have not been able to secure satisfactory results.

Many diseases have been investigated in different parts of the country during the year, among the most important of these being an outbreak of anthrax in southern California. This disease, which has long created havoc in the southern Mississippi Valley, is now found to be indigenous in California and probably in other parts of the country. The area involved is large and the losses very serious.

The nature of this disease is now well understood, and it is known that the micro-organism which causes it forms spores, and these retain their vitality in the soil for many years. On such soils the pasture and hay are infected and produce the disease in the animals which feed upon them.

Thus far no practical way of freeing much of the infected section from this contagion has been discovered, and the only method now known of preventing the disease is to vaccinate the animals according to the method discovered by Pasteur. Unfortunately the farmers of this country have no place to which they can apply for such vaccine. The Department could supply it if it had a suitable laboratory in which it could be prepared. As I have repeatedly stated, the laboratory now used by the Bureau of Animal Industry is located under the roof of the Department building, and is not a proper place to work with those forms of contagion which are dangerous to human health. For this reason we have been unable to supply these wants, and we have also been unable to investigate other similar diseases of animals, such as tuberculosis, glanders, and actinomycosis, which are also dangerous to human health.

There is consequently urgent need of a laboratory for this class of work. There is very much that should be done for the elucidation of questions connected with the prevention and treatment of such diseases, which can not be undertaken until proper laboratory facilities are furnished. The need for such a laboratory is becoming more apparent every year, as numerous demands are made upon the Department to investigate diseases and to furnish such means as may be possible for their prevention.

With the establishment of experiment stations in the different States there is a demand for persons qualified to make investigations of the diseases of animals, in particular the contagious diseases. At present the facilities for instruction in this country are very limited, and every one finds before undertaking such work that it is necessary to spend considerable time studying in the laboratories of Europe before they feel competent to accept such a position. If a suitable laboratory was established at this Department the educational feature might be made one of very great importance, and persons might spend a sufficient time working in it to acquire the methods used in this class of investigations, and in that way avoid the expenses incident to a visit to Europe. There are many now engaged in the experimental work in the stations of the various States who would be glad to devote a few weeks each year to such laboratory practice, and it would undoubtedly be of much value to them in the work which they are required to do. Probably offering such facilities would do more than almost any other measure that could be devised to advance the condition of veterinary sanitary science in this country.

The quarantine of imported cattle, still administered by this Bureau, has been in successful operation during the year. Increased precautions have been adopted to prevent the introdution of contagious diseases, and it is believed that there is no longer any danger of this in connection with the animals which pass through the quarantine stations. Since the quarantine has been operated under the direction of this Department the introduction of the diseases usually classed as contagious has been entirely prevented.

DIVISION OF ENTOMOLOGY.

The past year has been one of the busiest in the history of this division, although no one preponderating investigation has been carried on. The main work has been as follows:

Additional investigations have been made upon the subject of the Fluted Scale or Cottony Cushion-scale of California, and particularly in the direction of remedies, and the gas treatment has been developed to a practical outcome by an agent stationed at Los Angeles. Through the assistance of Mr. F. S. Crawford, of Adelaide, South Australia, an Australian parasite of this destructive pest has been introduced, though it is as yet too early to say with what practical results. The Department was prevented by a clause in the appropriation bill from sending an agent to Australia for the purpose of gathering further information upon the subject of the Australian parasites of this insect, but, fortunately, the State Department has been able, through the Melbourne Exposition fund, to assist us in this direction, and an agent of the division sailed in August with instructions to make a most careful exploration of the proper localities, to collect all the information possible, and to make arrangements for and to superintend the shipping of live parasites to San Francisco. Up to the present time he has met with most gratifying success. By careful search he soon collected over 10,000 fluted scales, fully 50 per cent. of which contained living parasites, and forwarded them by steamer as a first shipment. This installment arrived in Los Angeles in November, the scales were colonized upon orange trees, and up to the latest writing over one hundred living parasites had emerged. Thus the experiment promises every success.

The entomologist has not considered himself quite ready to publish the result of the Hop Louse investigation which, in my last report, I announced had been practically finished last season. A few additional observations were considered necessary in order to render his report perfect, and these have been made the present season, and the report as a whole will doubtless be published in my complete report for 1888. No investigation has ever been undertaken by the division that has been brought to a more satisfactory conclusion than this one.

The great damage done to peaches and many of the crops in Florida and Georgia by the work of certain root-infesting Nematode

worms of the family Anguillilidæ has been very marked for the last two or three years; and as no other division of the Department seemed better fitted for the carrying on of the investigation, the entomologist has undertaken it, and a report is now ready for publication.

The ravages of the Cotton and Boll worm upon the tomato crop in certain portions of the State of Mississippi formed the subject of a special petition on the part of one of the State societies to this Department, and the investigation of this subject has also been carried on during the season by this division.

The ravages of the Rocky Mountain Locust or Western Grasshopper in Minnesota were early called to the attention of the Department, but inasmuch as an assistant from the division of entomology had just been appointed to a State position at the experiment station at Saint Anthony's Park it was not considered necessary for the Department to interfere with his work, especially as the State authorities were exceptionally energetic in their endeavors to suppress the plague. An agent of the division, however, who has for many years paid special attention to this pest and the group of insects to which it belongs, was sent on a trip through the Northwest in order to ascertain the exact condition of affairs and in order to enable us to predict for the coming season. The conclusions which the entomologist has hitherto drawn from similar observations have been uniformly justified by subsequent experience, and as a result of this year's investigations he considers the outlook for the coming year to be most favorable.

In addition to the above, further investigations have been made upon the Buffalo Gnat in the Southwest; upon insects injurious to cereal crops; upon insects injurious to live-stock in general; and the work upon the bibliography of economic entomology has been continued.

The correspondence upon the subject of insects has been exceptionally large, and over three thousand five hundred letters have been received and answered. The majority of these letters are accompanied by specimens, and the mounting and rearing of these specimens and the care and labor of making accurate notes of their habits is very great.

Owing to the lack of specific appropriation it has been necessary to discontinue the apicultural experiment station. This is to be regretted, as the station has done good work and as it accomplished results of considerable benefit to this extensive and growing industry. The division stands ready to resume this work at any time when Congress shall make appropriation for it.

The publications of the division during the year have been more than ever called for, and represent a large variety of subjects intrusted to this important division.

The necessity for some speedy and regular means of publication in which might be printed notes, reports of the progress of investigations, and short articles upon entomological subjects which are either too limited in scope or too disconnected to be used in the annual report or in the special bulletins of the division, originated a periodical bulletin, six numbers of which have been published, and the character of the numbers and favorable comments of the agricultural press, by farmers, and by workers in agricultural entomology have borne out the prophecy of the entomologist in the introductory number to the effect that so far as the interests of economic entomology are concerned we have instituted so far no reform that will be productive of more general good or will give more general satisfaction. The numbers up to the present time have consisted of two signatures each and have been plentifully illustrated, a prominent feature being extracts from the correspondence of the division with farmers and others on the subject of injurious insects.

SILK.

For the past five years the Department of Agriculture has been carrying on a series of experiments with a view of testing the feasibility of profitable silk reeling in this country, thus promoting, if successful, a market for American grown cocoons. For two years these experiments were made at three different points, namely, San Francisco, New Orleans, and Philadelphia, with a view of establishing filatures at those places. The result of having such experiments conducted at remote points was not encouraging, as has been heretofore shown in the reports of this Department. Some three years ago there seemed to be a prospect of overcoming many of the difficulties which had been encountered in the earlier attempts, through the use of the Serrell automatic silk-reeling machinery. Congress authorized me to establish a silk filature in immediate connection with the Department at Washington, where it could be directly superintended by the entomologist and Mr. Philip Walker. This gave the Department an opportunity to thoroughly test the merits of the machinery referred to.

At the time these later experiments were inaugurated I felt that two years' experimentation would enable me to definitely determine whether, with this improved machinery, the matter of labor could be sufficiently economized and minimized to make silk reeling profitable in the United States. Owing to the difficulty which usually arises of adjusting foreign-built machinery to our methods, of teaching labor to work in an entirely new field, so far as this country is concerned, of explaining to the thousands of cocoon growers from whom the Department purchased cocoons the precise necessities of the business in order to secure the best results, and of many and various vicissitudes and contingencies which it is not necessary to

refer to in detail, the results of these two years of experiments were not satisfactory when considered from a commercial point of view. At this time the Department was informed of certain improvements then being perfected in the Serrell machine which again seemed to promise well, and to meet some of the difficulties which we had encountered, and in order to enable the Department to test the improved machine, Congress again provided the requisite authority and money for a continuation of these experiments. With these I have introduced the improvements alluded to and in conjunction therewith have established certain choking stations at different points in the West, or in the centers of silk culture, where the cocoons purchased by the Department might be more intelligently handled and choked before their shipment to the Department.

Pending the investigations under these new conditions, the Department was authorized by Congress to make an exhibit at the late Cincinnati Exposition. The Department determined to transfer a portion of this machinery to Cincinnati to be there put in daily operation as a part of the Department's exhibit, fully cognizant that such a step would materially interfere with the profitable results of the year's work, which had already been jeopardized by the lateness of the season when the appropriation became available; but aware also that the Exposition would be visited by thousands of those who either do or can raise cocoons, and that there they might witness the operations of the machinery and through this illustration as well as personal explanation learn those requirements which would be mutually beneficial. Owing to this fact and to the further fact that the improvements referred to have not fully met the difficulties which we have encountered, it would not be fair to this young industry to measure its probable future by what we have accomplished this year. We have devised certain improvements ourselves, and are now engaged in their development and trial. And I have asked for a further appropriation in order to determine whether the improvements made by the inventor, those made by ourselves, and those at present in the stage of conception here and elsewhere are to affect the main object of this experiment, and whether it is likely from the results achieved, and with the necessary encouragement, the United States is to add the silk industry to its other resources and enter the markets in competition with the silk-growing sections of the Old World.

DIVISION OF CHEMISTRY.

The investigations of the division of chemistry during the past year have continued in the general lines indicated in my last report. Extensive analyses have been made of the sorghum plant at Rio Grande, N. J., Kenner, La., Conway Springs, Douglass, and Sterling, Kans. The object of these investigations has been twofold: First,

to secure an accurate idea of the constitution of sorghum cane in respect of its properties for sugar making; and, second, to develop the cane in the direction of improvement by seed selection and other means. These investigations have now been completed and edited, and are in the hands of the printer, and will appear as Bulletin No. 20 of the chemical division.

Adulteration of foods.—The work in the adulteration of foods has been confined almost exclusively to the continuing of the investigations of baking powders, tea, coffee, and chocolate, and of lard. The investigations of this last product have been very extensive and the work is now completed and will shortly appear as Part 4 of Bulletin No. 13.

In addition to the above general lines of investigation a large amount of miscellaneous work has been done, the greater part of which has been in the line marked out by the Association of Official Agricultural Chemists for the determination of the various constituents in dairy products, cattle foods, and commercial fertilizers. The work of the Department in the above line has been published as Bulletin No. 19 of the chemical division.

The necessity for more commodious and healthful quarters for the chemists of the Department increases each year, and an early provision should be made for a laboratory especially constructed for this kind of investigation.

EXPERIMENTS IN THE MANUFACTURE OF SUGAR.

The great drain upon the resources of the country on account of our expenditures for sugar has long directed the attention of economic agriculture to the possibility of producing at home all or a greater part of the sugar consumed. The necessity for this would not be so great did we procure our sugar from countries taking an equal value of our own products; but this, unfortunately, is not the case. The greater part of our sugar comes from Cuba and the adjacent islands, and the balance of trade is overwhelmingly in their favor. The money which we pay for sugar, and which will soon reach $100,000,000 annually, is taken from our wealth, and we receive for it no adequate return. Even the machinery with which the sugar we eat is made is supplied only in small part by American manufacturers. The ponderous mills used in the tropical islands for crushing the cane and the systems of evaporating apparatus are chiefly built in England and France—countries which rely nearly exclusively on the sugar-beet to supply them with sweets. This condition of affairs is worthy of grave consideration, and no greater service could be rendered the agricultural and other industries of our country than by the establishment of an indigenous sugar industry.

The wisdom of foreign nations has been shown in similar directions by the development of the beet-sugar industry. The sugar-

beet a few years ago was a plant not notably rich in sugar and affording a juice which was little amenable to treatment. Under the fostering care of the French and German Governments, however, the sugar-beet has become a plant but little inferior to the sugar-cane of the tropics as a producer of sugar. With the aid of State experiment stations and the help of State schools of instruction the production of beet-sugar has become a scientific procedure, reflecting alike credit on the governments which have fostered the industry and the men who have devoted their labor and ability to its development.

In the United States the area which can possibly be devoted to the production of sugar cane is a limited one. Small portions of Florida, Louisiana, and Texas only can hope to compete with the tropics in the production of cane sugar. It is believed, however, that by the adoption of the processes introduced by the Department and the spread of a more scientific agriculture the quantity of cane sugar produced can be vastly increased. Since the Department first instituted a regular chemical control of a sugar factory in Louisiana the production of cane richer in sugar has been secured, the method of manufacture rendered more effective and economical, and the interest of the planters enlisted in securing a more scientific method of manufacture. Not the least important result of the work of the Department in this direction has been the establishment of a State sugar experiment station in Louisiana, the result of the interest in scientific sugar-making awakened by the work of the Department.

The quantity of sugar afforded by the maple forests of our country is necessarily limited, and it can not be considered as an important factor in the sugar problem from a commercial view. Doubtless the quantity of the product can be greatly increased, but the increase at best can be but slow. Maple sugar will continue to be valuable for its quality rather than quantity.

There are many parts of our country which are well adapted to the culture of the sugar-beet, and we may hope to see in the near future a very considerable development of the industry. Already on the Pacific coast beet sugar has been made successfully for several years, and an additional impetus has recently been given to the industry by a gentleman of well-known energy and great wealth. Not only in California, but also in Oregon and Washington Territory are found extensive localities where a beet rich in sugar can be grown. On this side of the Rocky Mountains, northern Indiana, southern and western Michigan, northern Ohio, and New York also present soil and climate favorable to the culture of the sugar-beet. It is not a vain hope, therefore, which leads us to expect a considerable development of this valuable industry within the next few years.

One of the most promising sources of sugar, however, for home consumption, is found in the sorghum plant. For many years the Department of Agriculture has given much attention to the investi-

gation of the sugar-producing qualities of the sorghum. These investigations have been both of a scientific and technical nature. Many of them have resulted in most discouraging results; either the poor quality of the cane or the defective character of the machinery prevented the successful manufacture of sugar on an economical basis. A few years ago, when the old process of extracting the juice by pressing between rollers was still in vogue, the sorghum-sugar industry was in a moribund condition. A great deal of private capital had been invested in manufacturing enterprises, and these investments all proved disastrous.

The Department of Agriculture, however, was determined to save this industry if possible, and, with this idea in view, it was determined to make a study of the process of diffusion as applied to the extraction of saccharine juices from sorghum cane. This process differs essentially from the old milling process. In diffusion, the canes are cut into fine pieces (the finer the better) and subjected, in closed vessels, to successive charges of hot water. By this process—for the details of which the bulletins of the Department, of the division of chemistry, can be consulted—the sugar of the cane is almost completely extracted in a condition favorable to epuration and condensation. During the past four years the Department has labored steadily, often under the most adverse circumstances, to perfect this process.

The first year's work during my incumbency of office was productive of two valuable results. The first of these was to show that the method of cutting the cane first employed was wholly impracticable. The second proved that the style of diffusion battery employed for the sugar-beet was inapplicable to sorghum cane. This result could only have been learned by actual trial, and it was a fortunate thing that so costly an experience should have been secured at public expense rather than at the financial ruin of private individuals, with its discouraging effects upon the industry at large. The second year's trial resulted in a complete removal of the mechanical difficulties which had been encountered in the operation of the diffusion battery. The improvement, however, in the cutting apparatus was not sufficiently great to secure successful operation of that part of the machinery.

At this juncture the ingenuity of a gentleman not connected with the Department at that time helped us out of our difficulty, and the machinery and apparatus devised by Mr. H. A. Hughes, of Rio Grande, N. J., and at once adopted by the Department, has, with some slight modifications, proved completely successful in cutting and cleaning the sorghum cane and fitting it for the diffusion battery. The difficulties which the agents of the Department have incurred in this work can scarcely be appreciated by those who are not acquainted with the details of the experiments. Every problem con-

nected with the successful conduct of the work had to be approached along unknown lines of observation, and as a consequence failure more often attended the results of the work than success. Not only was it necessary to contend with these chemical and mechanical difficulties, but also the impatience of those who were interested in the success of the work, which was often manifested in such a way as to positively hinder the progress therein.

Attempts were also made at this time to introduce the process of diffusion for the manufacture of sugar from sugar-cane. Guided by the experience obtained in the study of the sorghum problem, the experiments in the application of diffusion to sugar-cane proved speedily successful. During the season of 1887 the Department succeeded in manufacturing, on a commercial scale, as high as 230 pounds of sugar per ton of cane, a quantity which seems almost marvelous when compared with the average results obtained by milling in Louisiana. As a result of this experiment two large plantations in the South, one in Louisiana and one in Texas, have introduced the diffusion system to the exclusion of the mill. The increase in the output of sugar is so great, as compared with the additional expense of evaporation, as to indicate a speedy displacement, throughout the entire sugar region of the South, of the old process by the new.

Not the least important of the points determined by the investigations of the Department during the last few years is the limitation of the region in which it appears that sorghum can be grown as a sugar-producing plant. In the earlier investigations made in this line it was announced that sorghum could be successfully grown as a sugar-producing plant in any locality which would produce maize. It is true that sorghum will grow and mature in nearly all localities in which Indian corn will ripen. The past researches of the Department, however, have emphasized the fact that not only the growth of the plant but the time required for its economical manufacture must be taken into consideration. In localities subject to severe and early frosts the season for the manufacture of sorghum sugar is so limited in extent as to make the successful manufacture of sugar almost if not quite impossible. It seems, therefore, that sorghum-sugar factories should be established only in those portions of the country where it is reasonably certain that no severe freeze will occur before the 1st of November.

Another important point in regard to the sorghum-sugar industry is found in the fact that sorghum appears to flourish in regions too hot and dry for the successful production of maize. The western and southern portions of Kansas seem to be peculiarly well-adapted to the growth of sorghum, and it will doubtless prove true that throughout the Indian Territory, portions of Texas, and in many other localities in the United States similar suitable soil and climatic conditions will be found.

The area of land necessary to produce the whole of the sugar consumed in the United States will probably not exceed four or five million acres. It is therefore seen that those localities which are most favorable to the production of sugar should be selected for this purpose. Important points in the production of sorghum for sugar have been developed by the experience of the past season in southwestern Kansas. At Douglass and Conway Springs, where the Department had experiment stations, the hot, dry weather of July and August cut short the crop of Indian corn, in some localities producing almost a complete failure thereof. The sorghum crop, however, grew and flourished throughout this dry season and the yeild was a fair average. The importance of this fact to the semi-arid regions in the localities I have mentioned can not well be overestimated.

The easy variability of the sorghum plant is also a point which has received a great deal of attention in the investigations carried on by the Department. The fact that sorghum often shows a sugar-producing quality almost equal to that of sugar-cane has been pointed out in our official bulletins. Its tendency also to yield a product unfit for sugar-making has been equally the subject of study. All the principles of scientific agriculture go to show that in a plant of wide variations it is possible to secure and transmit the good qualities of the plant in such a way as to produce a variety which will retain, under proper conditions, the very best qualities of the natural variations. This being the case there is every reason to believe, as has so often been pointed out in the bulletins of the Department, that it is possible to develop a variety or varieties of sorghum which will tend to show a maximum content of crystallizable sugar and a minimum content of substances not sugar in the juice. It was in the line of such investigation that the experiment station at Sterling was established during the last season, where most valuable work was done in determining the very points just mentioned.

The further investigation of the problem of the production of our own sugar it seems to me should be continued in the following directions: First, the establishment of a special experiment station in a suitable locality for the further study of the variations in the sorghum plant with a view to the perpetuity of those qualities which tend to produce a plant best suited to the manufacture of sugar. Such a station, in order to secure proper results, should be established for a term of years, so that the problem might be subjected to a thorough investigation.

Second. In order to avoid financial disasters in the conduct of the business a school should be established in which instruction could be given in the proper method of raising and manufacturing sorghum, sugar-cane, and the sugar-beet. This combined scientific and technical instruction would prepare a large number of persons for taking charge of sugar factories and operating them scientifically and

economically. The danger of undertaking such a business as the manufacture of sugar without a thorough knowledge of the conditions which underlie it has been illustrated a sufficient number of times in this country by the financial ruin of those who have put their money into sugar factories. It is believed that the Department of Agriculture could not do a more valuable work for the promotion of the sugar industry than in preparing suitable persons for the work indicated.

During the past year I have been credibly informed that the sugar factory at Fort Scott, Kans., using largely the machinery erected by the Department, has succeeded in manufacturing sugar from sorghum at a profit. During the past manufacturing season, at the request of the manager of the Fort Scott factory, I have permitted them to use the machinery belonging to the Department of Agriculture without cost. This machinery consists of a diffusion battery and a large number of pumps, engines, centrifugal machines, and other apparatus. I sincerely regret that, being accorded the use of this machinery by the courtesy of the Department, they should have refused to make known for the public benefit the practical results of their work. This action shows that it would be much better for public interests if all experiments conducted by the Department could be made wholly independent of any connection with private capital. If sugar can be manufactured profitably in this case it can be in every other where proper machinery is employed and skilled labor used.

I have made this brief review of the condition of the sugar problem with the hope of securing a still greater prosperity for the sugar industry of the United States with the ultimate object of producing at home all the sugar which we consume.

ADULTERATED FOOD.

On assuming the duties of my office I was impressed with the extent of food adulteration and the injury worked thereby to the agriculturists of the country. In order to determine the nature of adulterations used in food and the best methods of detecting them the chemist of the Department was directed to a make a thorough investigation of this subject. The results of these investigations will be published as Bulletin 13 of the chemical division, three parts of which have already been issued from the press and the remainder of which is in an advanced state of preparation.

Up to the present time the investigations of the Department have revealed the fact that the adulterations practiced are, for the greater part, innocent in effect upon the health of the consumer. The sole object of adulteration seems to be to afford a cheaper article of food under the form and name of the genuine article. The fraud is there-

fore one of a financial nature, and happily few cases have been discovered of admixtures with food of substances deleterious to health.

As an illustration of the character of adulteration I may cite the case of lard. Lard is certain parts of the fat of the hog separated by means of heat from the other tissues of the animal and purified by allowing to stand in a melted state until all sedentary matter has gathered at the bottom of the tank. Under the head of "refined lard," however, there is found in commerce a large quantity of a substance sold as lard which is a mixture of pure lard with stearine and cotton oil in varying proportions. As far as our observations have extended this mixture known as refined lard is equally as digestible and wholesome as the pure article. It can also occupy with success the place of lard in many culinary operations. The cotton oil, however, being much cheaper than pure lard, enables this product to be placed upon the market at a cost much less than that of pure lard. The only objection to its use, therefore, that can be urged is that it is sold under a wrong name and for an article which it is not.

I can see no possible objection to the manufacture of a mixed lard or compound lard, the components of which are well known to the purchasers, who are perfectly well acquainted with the composition of the article which they are buying. There is no doubt, however, that many persons who have purchased the so-called refined lards of commerce have done so with the understanding that they were ordinary lards which had been subjected to a process of refinement. It seems but just that the producers of pure lard should be protected from a competition of this kind. The investigations of the Department have shown the character of these adulterations and have established safe and certain methods for their detection.

Other subjects investigated have been butter and milk, fermented drinks, spices and condiments, baking powders, sugar, honey, and molasses, and tea, coffee, and chocolate. In many of these substances extensive adulterations have been found, and in a short time the results of the work will be laid before the public. I need hardly emphasize again the importance of such work as this to the farming interests of the country and the difficulty of securing a proper conduct of it outside of the national Department of Agriculture. The character of the investigations requires painstaking and laborious laboratory work, which is of such an extensive nature as to be almost excluded from the work of the State experiment stations. It is work of this kind which seems to be the special province of investigations carried on by the Department.

AGRICULTURAL STATISTICS.

The statistical division of the Department has been subjected to extraordinary demands during the past year. The ordinary work of collecting, collating, and recording the official and other facts of agri-

culture transpiring in America and throughout the world has been actively continued. The demands of associations and individuals for co-ordinated data illustrating the world's progress in agriculture has been constant and eager. The work of writing the crop history of the year as it is made by the activity of farmers and the changes of the seasons, thus forecasting intelligently the production that is to supply the wants of the United States, and also of such part of "the world" as may need whatever surplus is at hand, has been pushed with promptness and public appreciation.

An exception as to appreciation may be noted in the case of a class of speculators who deprecate any action by the Government which shall serve to protect farmers against their selfish schemes. The great body of middlemen, however, a necessary and useful class for the economical distribution of the products of the farm, are in full accord with the producers and consumers, the masses of the people, in desiring the most accurate and reliable information that can be obtained. It is gratifying that this branch of the service enjoys so fully the public confidence, at home and abroad, for reliability, accuracy, and promptness in crop reporting.

The year 1888 has been one of medium agricultural production. The corn crop had extraordinary promise until the time of earing, when it was injured somewhat upon the Atlantic coast by heavy storms of rain, and slightly from the same cause in the central belt of States. There was destruction by frost only on the northern border. The result is a crop of between 26 and 27 bushels per acre, slightly above a medium yield, and not surpassed in quality in the last eight years. The aggregate will fall little short of 2,000,000,000 bushels, and give a supply of 32 bushels per capita. Much of it is deficient in quality, especially the late planted, and in the districts of early frosts. The feeding value of corn is greatly depreciated.

Wheat, the cereal next to corn in importance, has been the subject of much apprehension. Injury to winter wheat threatened a marked reduction of the yield. A slow improvement occurred, and later development gave a greater weight of grain than the previous appearance of the plant had indicated. Spring wheat, on the contrary, started vigorously, giving a promise which was blighted by the meteorological vicissitudes of the later season. The result was a nearly average yield of winter wheat and a small yield of the spring variety, promising a final record not much exceeding 400,000,000 bushels of an average quality, reducing the effective product somewhat below that figure.

A large area in oats, with a moderate yield, assures a crop of unusual size, which has so varied uses that its market value is always relatively sustained, although used exclusively for domestic consumption. Other grains are in moderate supply. A crop of potatoes

of unusual magnitude, nearly 50 per cent. larger than that of last year, has been harvested.

The cotton area has been slightly increased. The crop is later in development than that of 1887, and the ultimate yield is not likely to be as large as that of last year, which produced 7,000,000 bales, yet it promises a sufficiently near approximation to supplement amply the cotton supply of the world for the coming year.

The supply of pasturage and hay has been ample in nearly all parts of the country, few localities having suffered from drought in the growing season. The pasturage of the ranges in the great public land areas has been comparatively good, though severely injured by overcrowding of immense herds in the recent years of speculation in range cattle. The reduction of carrying capacity of these public pastures is a serious temporary loss to meat production, and possibly a permanent impairment of the resources of the range. The indications all point to a gradual reduction of the size of these herds, and possibly the ultimate extinction of the free-range system.

The Statistician is engaged in the initiation of valuable work in illustrating by graphic methods the local distribution of crop production, and the rapid increase in its volume. A small statistical album will illustrate some of the prominent features of the work of the division, and larger maps and charts will show the advance in production and its relative local volume. There has been a constant demand for such aids in the study of agricultural statistics, by institutions of learning, public lecturers, and others, which could not be supplied from available resources until a small appropriation for a beginning in graphic illustration could be made. The variety and volume of our production, and its phenomenal increase in limited periods of time, emphasize the utility and indeed the necessity of such aids. It is hoped and confidently expected that much may be wisely accomplished in this direction in the immediate future.

BOTANICAL DIVISION.

The work of the Botanical Division has been prosecuted satisfactorily during the past year.

The spirit of inquiry among farmers and agriculturists is increasing. It is felt that in a country with such great variations of climate there must be a corresponding variety in the plants which are adapted to successful cultivation in different parts of the country. This is particularly the case with reference to grasses and forage plants. Information respecting these is being constantly sought, and to answer these inquiries is one of the main features of our work. For this purpose careful investigations are being made as to our native productions that we may understand our own resources, and inquiries are also made as to any additional benefits we may obtain from the introduction of foreign grasses and forage plants.

Changes and improvements in this direction are necessarily of slow growth, and the result of careful and protracted experiments. The great majority of cultivators are not so circumstanced as to devote the time and expense needed for such experiments, and hence arises the necessity of Government aid in this direction. I have previously advocated the establishment of stations for experimentation as to new grasses and forage plants, especially in the arid portions of the country. It is a pleasure to record the fact that a beginning has been made in this work. Among the recent appropriations to this Department was a moderate sum for the establishing of such stations.

It was determined that one of these stations should be located west of the one hundredth meridian. After a careful investigation a site was selected at Garden City, in southwestern Kansas, where a public-spirited citizen gave a free lease to the Government, for five years, of 160 acres of land on the high prairie 2 miles north of the city. This is so located that irrigation can be employed on such portions of the land as may be desirable. The object of the station is to make experiments with all kinds of grasses and forage plants which give promise of utility and of adaptation to the climatic conditions of the arid plains, and furnish a substitute for the scanty pasturage now existing. In order to secure the permanent settlement of this portion of the country it is highly important to ascertain what can be depended upon in the cultivation of the dry uplands where irrigation can not be applied. It is a question affecting the interests of thousands of settlers, and a matter of public interest generally.

I appointed Prof. J. A. Sewall, of Denver, as superintendent of the station, and, although late in the season, work was begun at once. Eighty acres were substantially fenced with barbed wire, 15 acres were plowed and prepared for seeding, a seed-house was erected, a portion was planted with sods of several kinds of grasses, an invoice of seeds has been procured from France, and a quantity of seeds of native grasses has been obtained in readiness for use at the proper time in the spring. The progress of these experiments will be watched with great interest, but definite results can not be expected without the allowance of a considerable period of time.

Arrangements have also been made with the trustees of the Mississippi Agricultural College to prosecute a course of experiments and trials with reference to the discovery of the best grasses for the climatic conditions of the South. These experiments will be commenced immediately, and be continued, it is hoped, until definite and satisfactory results are obtained.

It is gratifying to note also that a more liberal appropriation was granted for the improvement of the herbarium, and for acquiring a better acquaintance with the vegetation of the country, particularly

in new and little-known regions. It is very important, both from a practical and scientific point of view, that here at the seat of Government means should be available for obtaining full information respecting the productions and resources of the country.

It is certain that our numerous agricultural colleges will have many occasions to seek such information, and our ability to be helpful to them in this and other directions is the legitimate function of this division of the Department. I have to recommend, therefore, that liberal appropriations for the work of the division be continued.

SECTION OF VEGETABLE PATHOLOGY.

During the past year the duties of this section have been prosecuted with vigor; the correspondence has been steadily increased, and this, together with the regular routine office work, has consumed a large part of the time of the divisional force. Early in the season a report on the experiments made in 1887 on the treatment of downy mildew and black-rot of the grape vine was published, and the demand for this publication fully attests the interest felt in this investigation by those whom the work was intended to benefit.

In addition to the foregoing, the section has published a circular on fungicides, or remedies for plant diseases, and a report setting forth the history and progress of black-rot of the grape in America. The circular was prepared chiefly for the use of directors of agricultural experiment stations, and to answer the queries of many correspondents.

Papers on apple-scab, bitter-rot of apples, strawberry-leaf blight, beet rust, cotton-leaf blight, anthracnose of the bean, anthracnose of the raspberry, leaf-spot disease of the catalpa, black-spot on rose leaves, rose rust, powdery mildew of the gooseberry, smut and rust of Indian corn, etc., have been published in the annual report of the section for 1888. A report on the potato blight and rot has been prepared and is ready for publication. Material is now being collected for a report on the powdery mildews of the United States, and a second and enlarged edition of Bulletin No. 2 on fungus diseases of the vine.

During the greater part of the summer an agent has been at work in Montana collecting specimens of the economic fungi of that region. In this work particular attention has been given to the fungi of grasses, and arrangements have been made for distributing these among the various agricultural colleges and experiment stations.

Throughout the season experiments in the treatment of mildew and black-rot have been conducted by special agents located in New Jersey, Virginia, Missouri, and Texas, and the material these have furnished will form the basis of a report soon to be published.

Successful treatment of black-rot of grapes.—The experiments made under my directions at Vineland, N. J., and elsewhere during the

season have clearly demonstrated that black-rot—the scourge of the vineyardist—may be prevented by the proper application of Bordeaux mixture or other preparations of sulphate of copper.

While the efficacy of these remedies can no longer be doubted, it must be borne in mind that to successfully combat this disease it is absolutely necessary to thoroughly understand the habits of the fungus which is the direct cause of it. Every grape-grower, therefore, should first familiarize himself with the manner in which the fungus lives from year to year, how it gains access to the tissues of the leaves and fruit, and, once therein, produces rot. A course of treatment for this malady, which will be economical, practical, and efficacious, will be definitely indicated in a report now in preparation.

It is gratifying to announce that the importation of French spraying pumps and bellows for applying the various preparations of sulphate of copper has led to such a demand for these appliances, that a number of similar machines have been constructed here and are now on the market. Several of these are described in the report on the treatment of grape diseases, to which we have already referred.

As the work of the section progresses the necessity for extended field observations and experiments becomes more and more evident. It is true that laboratory investigations must be carried on, but in addition work in the field is absolutely necessary to insure practical results. A station located where a large number of economic plants could be cultivated, and in a region favorable to the development of fungous diseases, would be of untold value in the prosecution of the section's work. Here the work, which must now be intrusted entirely to special agents, located at various places and often depending entirely on written directions, could be carried on under the personal supervision of an experienced and competent director, and we could confidently expect that the practical results would be threefold what they are at present.

Such a station is almost an absolute necessity for making inoculations and for experimenting on the value and time for applying fungicides. For the past two years the money and energy of the section have been especially devoted to experimenting on the fungi affecting the grape, but requests are coming from farmers and gardeners all over the Union that we investigate the causes of, and try the effects of fungicides upon, other diseases. The root-rot and scab of the orange, the rust and bitter-rot of apples, the spot disease of the pear and quince, the strawberry rust and cotton blight, are but a few of the many diseases which are causing immense losses yearly to the farming community, and justly claim our attention. To reach definite results in all these diseases through the work of special agents alone will require an unnecessary outlay of time and money. Moreover, but few of the State experiment stations are at work in this

line, and it seems to devolve upon this Department to establish thorough and effective work in this most important field.

Peach "Yellows."—An investigation of this obscure and destructive malady was begun in July, 1887, by an agent of the section and has been prosecuted continually to date.

Very thorough examinations have been made in the orchards of Michigan, Maryland, and Delaware, and the orchards in some other States have been visited for special purposes. The results of these investigations have been embodied in a special report which is now ready for the printer. The disease is more widespread and destructive than was supposed, and is gradually extending the area of its influence. Hundreds of orchards on the Atlantic coast are being destroyed, and the entire industry of peach-growing in the northern part of the Chesapeake and Delaware Peninsula bids fair to be swept away if the cause of the disease can not be discovered and some means devised for keeping it in check.

An exhaustive microscopic and physiological study of the roots, trunks, branches, leaves, and fruit of both healthy and diseased trees, designed to throw light upon the nature of the malady, is now under way, and authority and means are requested to continue these and other investigations.

DIVISION OF GARDENS AND GROUNDS.

The work of this division consists largely in the care and keeping of the reservation under the control of the Department. This reservation contains upwards of 35 acres, every foot of which requires cultivation or care, except such portions as are occupied by buildings. The ornamentation of the grounds requires the yearly propagation of over 20,000 plants of various kinds. Merely ornamental plants are not propagated for general distribution, but only those which promise to be of economic, industrial, or commercial value. Of this latter class of plants there is a yearly average of 90,000 propagated, culivated, prepared, and mailed to various sections of the United States.

Particular attention is, at the present time, being given to the introduction and propagation of the best varieties of the European olive. The cultivation of olive trees and the manufacture of their products have become industries of considerable importance on the Pacific coast, and it is fairly presumed that equal success will follow the introduction of this plant in the Southern States, where climatic conditions are favorable to its growth.

The demand for semi-tropical and tropical plants of economic value for the most southern regions of the States is constantly increasing; these demands are recognized and met, as far as practicable; but applications for seeds and plants of strictly tropical species are not encouraged, from the fact that the limits of their profitable cult-

ure are so restricted, that no results of commercial importance can be hoped from their introduction; at the same time it is duly recognized that carefully-conducted experimental tests are necessary to truly demonstrate the adaptability or otherwise of plants to climates or locations other than those of their native habitats, so that practical tests continue to be made with plants whose prospective value warrants this experimentation.

DIVISION OF ECONOMIC ORNITHOLOGY AND MAMMALOGY.

The work of this division during the past year has been confined in the main to the collection and elaboration of material relating to the investigations mentioned in my last report.

A year ago two bulletins were ready for the printer, one on the English Sparrow, the other on Bird Migration in the Mississippi Valley. The latter work has been issued in the form of a compact octavo volume of 313 pages, accompanied with a hypsometric map of the Mississippi Valley, showing the positions of the observation stations. The manuscript of the bulletin on the English Sparrow is now in the hands of the Government Printer, and it is hoped that the bulletin will appear at an early date.

Since the publication of my last preliminary report a carefully conducted series of experiments in poisoning noxious birds was made by one of the assistant ornithologists, and the results were incorporated in the annual report of the division for 1887. In the same report appeared the results of a critical examination of the stomachs of more than one thousand hawks and owls, tabulated by the same assistant. The work in this direction has been continued during the past year, and another assistant has spent much time in the examination of the stomachs of crows. The results of all these examinations, together with copious notes on the food-habits of the species concerned, will appear in two special bulletins already in an advanced stage of preparation.

In undertaking to identify the stomach contents of fruit-eating and seed-eating birds it became evident at once that no substantial progress could be made without a reference collection of seeds, berries, and the pits of fruits. Such a carpological collection does not exist either in the Department of Agriculture or the U. S. National Museum; therefore it has been necessary for members of the division to collect this indispensable material in order to carry on the work of identifying the stomach contents of crows, blackbirds, and many other species.

Considerable progress has been made in arranging for publication the large amount of material in hand relating to the depredations of blackbirds, but this work, as well as that relating to the rice-bird or bobolink, is held back temporarily for lack of sufficient competent

field observation and experiment to complete the investigations and determine the economic status of the species.

Perhaps the most important feature of the work of the year has been the collection and arrangement of material for one or more bulletins on the Pocket Gophers and Ground Squirrels of the United States—a work of surpassing importance to the agriculturists of the Mississippi Valley, and, indeed, the whole of the western two-thirds of the continent, though the magnitude of the losses occasioned by these animals and the imperative demand for a remedy are almost unknown and entirely unappreciated in the Eastern States. During the past summer an energetic field agent has devoted much time to this work in Nebraska, Dakota, Wyoming, and Utah; and the ornithologist of the Department visited parts of Montana, Washington Territory, Oregon, and California in order to study personally the different phases of the problem there presented, as well as the remedial measures employed by the farmers of the region.

The attempt to remedy the gopher evil by the award of bounties has proved as useless as in the case of the rabbit plague and sparrow scourge; and the persistency with which this method is resorted to shows the necessity for a compilation of bounty laws and their results, at least in the United States. Such a compilation was begun two years ago in connection with the sparrow investigation, and has been continued since, the scope of the work being enlarged to cover all legislation directly affecting undomesticated birds and mammals.

The importation of exotic species was spoken of in my annual report for 1886. During the past year the division has collected considerable information relating to this subject, particularly to the colonization of Asiatic pheasants in the Pacific coast region. This information will appear in the report of the division for 1888.

The subject of the geographical distribution and migration of birds and mammals has received some attention during the year, but not a tithe of the consideration that its importance demands. The large and steadily increasing influx of material bearing on this and other subjects pertaining to the work of the division renders it impossible to give due consideration to any one branch of investigation without neglecting others.

Scores of thousands of small birds are killed each year by striking the light-houses along the coasts and lakes of the United States and Canada, and the keepers of these lights are requested to transmit to this division full accounts of the phenomena accompanying such catastrophes, together with specimens (heads and wings) of the birds killed. The material thus contributed is sufficient in itself to require the services of an assistant during the entire year, and when to this is added the equally valuable reports of many hundred voluntary inland observers throughout the United States and Canada, it will be seen that little can be accomplished with the present force of the

division, now almost exclusively occupied in the more purely economic phases of the work.

A not unimportant incidental feature of the routine work of the division consists in the identification of specimens of birds and mammals sent to the Department for this purpose. The number of specimens thus sent exceeded a thousand during the past year and is constantly increasing. It is hardly necessary to add that great good is done by thus diffusing among the people an accurate knowledge of the birds and mammals with which they are surrounded.

The literature of economic ornithology and mammalogy is both voluminous and scattered, and a competent person might profitably spend his entire time in collecting titles and references which would make this literature available.

Meanwhile general interest in the practical work of the division increases, and a very large item of office work is that which relates to the regular correspondence of the day. Upwards of two thousand six hundred letters have been written during the year, in addition to several thousand circular letters which have been sent out, and this is but one of several items which unite to give the routine office work of the division an importance disproportionate to its working force.

SEED DIVISION.

The work required in the management of the seed division is becoming more diversified and exacting than in former years. The questions referred to the division for answer, either in full or in brief, seem to keep pace with the ever-increasing number of letters embodying not only the results of experience with seeds received by the writers, but on other matters that seem to be more closely allied to the work of the seed division than to that of any other.

The gradually increasing number of reports received involves much additional labor to collate experiences, condense and classify them, with the view of getting as much practical information in as limited a space as possible. The work of securing reports from practical farmers, and their hearty co-operation, is becoming each season an easier task. This is to be accounted for largely on the ground that the intrinsic value of the seed sent out has been measurably increased since the practice of testing their germinating qualities has become an important and indispensable part of the regular work of the division.

The requirements of the organic law creating the Department of Agriculture are, "that it shall acquire and diffuse among the people of the United States useful information on subjects connected with agriculture, and procure, propagate, and distribute among the people new and valuable seeds and plants," and that the purchase and distribution of seed shall be confined to such seeds as are "rare and

uncommon to the country," or "such as can be made more profitable by frequent changes from one part of our country to another." Undoubtedly the primary object of the seed distribution is to give increased value to production, to ascertain the best geographical distribution of varieties, and to more rapidly introduce these into localities to which they are best adapted. A gratifying degree of progress has been made in the efforts to comply with the spirit of this law.

The method of testing the germinating qualities of seeds before payment is made for them has been continued, and is found indispensable as a means of protecting the Department from sending out worthless and inferior seeds.

Nothing can be more injurious to the agricultural interests of the nation than the wide dissemination of imperfect seed, and that which is untrue to name, either by professional seedsmen or by the Agricultural Department.

The Department seeds are now mainly distributed through the following channels: First, to constituents of members of Congress; second, to regular statistical correspondents; third, to experiment stations and agricultural societies; fourth, to experiment farmers; and, fifth, to miscellaneous applicants. In all cases, so far as it is possible, such seeds are selected and sent out as are known to be suited to the respective localities.

It has been made a rule of the division to send only such varieties of seeds as are asked for by those who desire them for experimental purposes, and are willing to make such reports as will enable the division to determine with considerable accuracy their value in the special localities where they may have been distributed.

At no time in the recent history of the Department have there been so many inquiries for seeds, especially forage and grass seeds, as have been referred to the division during the past year. These inquiries have arisen from a pressing need for such varieties as will thrive where the native grasses have failed, or where, from lack of moisture during the summer months, it is difficult or impossible to raise the ordinary grasses or forage plants. The effort made by the division to secure and distribute these seeds has been measurably successful, judging from the number of very satisfactory reports that are constantly being received. The producing of Florida-grown Teosinte seed, raised from seed sent out by the Department the previous year, has proved to be a step in the right direction.

The methods of distribution have been materially modified both in the increased number of varieties sent to constituents of members of Congress and in the manner of sending them, not only materially lessening the amount of clerical work required to address the seed packages, but by using sealed instead of tied packages, greater exemption from loss is secured while the seeds are in transit to their

point of destination. The system of lettering alphabetically the different varieties of grain, grasses, tobacco, cotton, and forage plants, adopted in August, 1885, whereby the varieties best adapted to special localities are designated for the guidance of the mailing clerk, has proved to be of great value in complying with the existing law relative to the proper distribution of seeds.

The system of apportioning the seeds has been perfected during the year by which members of Congress in Florida, southern California, or other sections lying in the same isothermal belt, receive only such seeds as are adapted to the climate, while members in the northern belt, instead of getting the same seed, receive its equivalent in varieties only adapted to a northern climate.

If the operations of the division are to be continued, then its most manifest and urgent need, in order that its influence for the promotion of advanced agriculture may be enhanced and its fullest value realized, is that of suitable experiment grounds, where imported or contributed seeds, or presumably new varieties, can be tested, and their identity or their proper nomenclature established, so that it may be definitely ascertained whether they are worthy of further propagation and distribution.

Notwithstanding all the improvements that have been introduced, however, the Commissioner is of the opinion that the experiment stations of the various States could carry on the work of testing and distributing seeds with more advantage to the agriculturists of the country than can possibly be effected by the seed division of this Department. The director of each station knows, or should know, the wants of each State and Territory. He is familiar with its climate and soil and knows what products it is adapted to raise. He is better qualified to judge of the class of seeds needed in his section than any one can be who is stationed at the capital of the nation. Hence I renew my recommendation of last year to so change the law as to transfer the distribution of seeds to the experiment stations of the various States and Territories.

FORESTRY DIVISION.

It is quite certain that there is hardly any division in the Department the work of which is more capable of expansion than the one charged with the forestry interests of the country.

For some ten years now it has become a matter of routine report to call attention to the needs of this part of our resources; to the importance of our forest areas in their natural and climatic aspect; to the necessity of forest management and forest planting. It seems that we are slow to respond to the warnings and admonitions and the signs of danger, because the danger is not immediate, and therefore is difficult to realize. Yet our neglect in paying proper atten-

tion to this subject now will certainly be felt by our nation in later years, as a similar neglect has been felt by other nations.

Having arrived at a stage where the natural wood crop in certain directions shows signs of exhaustion, the mere question of material supply becomes of national importance. The basis for an industry, such as that of lumber production and of wood-working establishments, which consumes an annual raw product the value of which may safely be placed at over one billion dollars, is certainly worthy of vigorous efforts to maintain in continuity. Still more is the interest of the community bound up in the forestry problem, where the forest by its position assumes similar functions, and ought to receive the same consideration from the community as those species of property which, like air, water, roads, etc., are administered with a view to common welfare. For whatever the theories, opinions, and beliefs of scientific authorities may be as to the futility of forest climatic influences, our farmers have felt them, as well as those in other parts of the globe. We may consider the influence of forest areas upon the distribution of waterflow and upon climatic conditions as well established beyond dispute as is their material value.

While we have gained a general idea of these facts, we are lacking sufficient data to estimate the position which the remaining natural forest crops and forest areas in our country maintain with regard to our requirements. Investigations in this direction would properly have formed the work of the division in its earlier stages, in order to create a basis for further action on the part of the Government. Yet the multifarious directions into which the activity of the division was called, and insufficient funds have hitherto prevented such systematic work.

With the recognition of the restrictions which are imposed upon it by the limited appropriation at my command for this line of research, the work of the division is gradually assuming definite shape in such scientific investigations as may eventually serve for a rational basis of practical forest management; abandoning, for the present, work in many directions that it would be desirable and profitable to prosecute, if expansion and limitation were dictated by proper economy.

The demand for different and more extended work on the part of the division will be in vain until the means for such work are granted. Practical work might be considered the protection and proper administration of our Government timber lands, the value and superlative importance of which still remain to be considered by Congress. The planting to forest of military reservations in the Western plains would not only be a proper and practical disposition of this national property, and would render it more valuable, but at the same time would serve as a school to the settlers in those regions as experimental grounds in forestry, and, besides, open

another useful and practical field of activity for the division by furnishing plant material for distribution.

Distribution of plant material, which other nations practice with the most desirable results, and which, under a well elaborated plan devised by the division last year, promised to be a valuable part of the work of the division, had to be abandoned this year entirely because the sending of small packages of seed, to which a small part of the appropriation might have been devoted, could hardly be considered of practical value as an encouragement to forestry.

Our need in forestry is not, as it is in agriculture, to introduce new kinds so much as it is to furnish in sufficient quantity and quality material of well proved species to our pioneers in the treeless sections of the country.

Experimentation in forestry, such as might be carried on in connection with the planting of large areas as proposed, and which could be made of great service to the forest planters of the West, is also precluded by the deficiency of working funds.

While the need and value of reliable knowledge in regard to forest supplies, forest consumption, and forest renewal is not to be underestimated, statistical inquiries have for the most part been abandoned by the division, because the partial returns which alone can result from the methods of collecting statistics at the disposition of the division can not bring us any nearer to positive knowledge beyond the general fact that our forest supplies are being decimated by fire and ax at a rate exceeding that of natural reproduction, which we have known for some time.

A valuable report on the Forest Conditions of the Rocky Mountain Region has been issued during the year as Bulletin No. 2. It gains special importance from the fact that most of the timber land belonging to the National Government is located in that region, and that the need and methods of reform in its disposal and management are presented in the report with rational argument and in an unequivocal manner.

The annual report of the forestry division was issued as a separate publication on account of its special interest. It has received the highest commendation in this country and abroad, and contains much information in regard to the art of forestry which must be welcome to the forest planter. It also bears testimony to the proposition that devotion to the scientific investigations upon which the practice is to be built may be considered the proper limitation of the sphere of a forestry division without forests and without adequate funds.

The investigations which have principally occupied the division this year lie in two directions—biological studies, which will allow us to judge of the different methods by which the crop of various timbers should be grown, and technological investigations, which will ac-

quaint us with the nature of the crop and the conditions which influence its quality.

These latter investigations, which have already yielded interesting results, are perhaps among the more fruitful; and it is strange that their close relation to forestry and their pertinency should have been overlooked.

The properties upon which the use of wood in the arts is based should be well known to the forest-grower if he wishes to produce a crop of given quality useful for definite purposes. But, as a matter of fact, our ignorance in this direction is most astonishing and has been fruitful in fostering a wasteful use of our natural forest, while the same ignorance misleads even the forest-planter of to-day in choosing the timber he plants and the locality to which he adapts it.

As usual, a considerable missionary work has fallen to the division. The calls for the representation of the facts concerning forestry at public meetings are constantly increasing; and I have, as far as practicable, detailed the chief of the division to attend such meetings and by personal contact and impression widen among our people the conception of the meaning of this economical science, a knowledge and appreciation of which are growing more and more necessary from year to year.

DIVISION OF MICROSCOPY.

The work of this division for the current year has been largely in the line of microscopical investigation of adulterations of food-stuffs, principally of the condiments of commerce, which will be illustrated in the forthcoming report of the division by means of microphotographs and colored drawings, showing the cellular structure of the berries, roots, etc., and their pulverizations, and, for purposes of comparison, a series of photographs and drawings showing the structural forms of the principal adulterants used.

Examinations have been made from time to time, as occasion demanded, of other food-stuffs, particularly of butter and of lard, as provided for by act of Congress.

Correspondence relating to mushrooms has increased, and numerous specimens have been sent to the division for identification as to edibility.

A series of experiments with oils and fats has had an especially interesting result in what the microscopist describes as the incidental discovery of the fluorescence, under a given treatment, of certain oils and fats, and a beginning of a classification of them, under the head of fluorescent and non-fluorescent, introducing a new and important feature in the detection of their adulterations.

The work on textile fibers and textile fabrics continues; such results as have been already reached will be set forth with illustrations.

A large increase has been made in the collection of fibers, both of domestic and foreign growth.

Following the instructions to that effect, an exhibit was prepared by this division and forwarded to the Exposition at Cincinnati, Ohio. This exhibit consisted of about three hundred plates relating to microscopy and the work of the division.

DIVISION OF POMOLOGY.

The results of another year's work of this division add new encouragement to the hopes entertained when I established this division a little over two years ago, and to which I have heretofore given expression. The fruit-growers of the entire country have entered into hearty co-operation with it, and by correspondence and in person have expressed their satisfaction with its working plans.

TROPICAL AND SEMI-TROPICAL FRUITS.

The cultivation of tropical and semi-tropical fruits in the United States is yet in its infancy in this country, and the importance of making a thorough investigation of the facts regarding their culture so far as experiments have been made, and placing such information in the hands of those interested in this subject, has caused me to have a special report prepared during the year, and issued as Bulletin No. 1, which has been widely distributed. It is hoped that the culture of these, and many kinds of fruits now unknown or but poorly understood by the majority of our people who live where they may be grown, may be thereby materially advanced. Notably among these is the lemon, which succeeds admirably in the warmer portions of California and Florida. During the fiscal year ending June 30, 1887, $3,835,147 were paid to foreign countries for this fruit alone, and this in the face of the fact that we have sufficient territory suitable to produce all that our markets demand.

Seedling varieties of superior excellence or American origin and the best of those grown in Europe are being placed in the hands of intelligent experimenters for the purpose of encouraging the industry. The same is in some sense true regarding the pine-apple, the guava, the banana, and many other tropical fruits, all of which are receiving the most careful attention by this division.

HARDY FRUITS IN THE NORTHWEST.

That portion of the country lying west of the Great Lakes east of the Rocky Mountains and north of the forty-second parallel are in especial need of varieties of fruits which will withstand the peculiarly severe winter climate which renders many of the older varieties worthless there. The same is true of the extreme northern portion of the New England States.

In the year 1860 this Department began the importation of varieties from Russia to meet this requirement. As many of these varieties have been bearing for several years, a special agent was appointed to visit the Northern States, and carefully examine into the merits of such fruits as he could find, and prepare a report. This report is embodied in Bulletin No. 2 of this division.

Investigations and experiments are to be continued by the division, and all possible assistance rendered to the fruit-growers of these regions.

OUR WILD FRUITS.

There is perhaps no country outside the tropics having so great a wealth of natural fruits as our own. To properly investigate them in their natural habitats, and induce experimentation and development with them in the garden, orchard, and vineyard, is within the province of the pomological division. Something has already been done in this direction, and plans have been made and are being executed, which it is expected will result in increased scientific knowledge of these fruits and in their improvement under cultivation.

Work is now well advanced on a monograph of the wild grapes, and within the coming year a monograph of this genus will be ready for publication, which will be of unusual interest to scientists and practical vineyardists. It will be accompanied with complete typical illustrations in colors, showing every species of grape native in the United States.

FRUITS EXAMINED AND NAMED.

During the last year there have been received by the pomologist 492 packages of fruits, containing in the aggregate fully 10,000 specimens. Every State and Territory except Wyoming and Nevada has been represented thereby, and many have been received from foreign countries. All have been studied and compared and accurate records kept. A large number were sent to be named, which the division has been able to do in nearly every case.

CLERICAL ASSISTANCE.

The increasing necessity for an assistant and additional clerical force in this division is very urgent, and it is hoped that Congress may provide for the same.

NEW LABORATORY.

I renew the recommendations made in my reports of last year and of the year before, that provision be made for the erection on the grounds of this Department of a suitable building for laboratory purposes. The underlying reasons are of the most commanding and urgent character.

The present building, originally designed for the offices of the

purely administrative and clerical branches of the Department of Agriculture, has, with the lapse of time, and in consequence of added functions imposed by Congress, been partially surrendered for uses to which it is in no respect adapted. The discomfort arising from the proximity of a chemical laboratory in the basement and an animal dissecting room in the garret is least among the arguments which present themselves in behalf of a new and proper building. The noxious odors incident to the chemical analyses, or of *post-mortem* diagnoses of animal diseases, imperil human health and perhaps human life. The conveniences and even the simple requisites of light, ventilation, and equable temperature, so essential to some of the delicate operations of scientists and experts, are conspicuously lacking in the present quarters of the bureaus of chemistry and animal industry. Some fields of investigation which promise important economic results can hardly be entered upon under the present circumstances, while not infrequently the work of weeks of careful study is lost by reason of changes of temperature against which it is impossible to guard. Indeed, until greater security is afforded we are deterred from making any experiments with such diseases as anthrax, glanders, antinomycosis, and others transmissible to man. Basement rooms are needed with cement or asphalt floors for keeping small animals for experimental purposes; rooms are needed for the burning of dangerous material from diseased animals, for the testing of disinfectants, for the storing of pathological material designed to illustrate phases of disease, and to instruct those who come to the Department for information.

No less important is it that the Division of Entomology be accommodated with more desirable work-rooms. The functions of this branch of the Deparament, though less obnoxious and repulsive than some of those mentioned in connection with the others, are essentially related to the laboratory. The correspondence and the clerical and literary work of this division are carried on in two rooms of the second floor of this building, and in space temporarily partitioned off from the main library. Experiments in silk-culture are conducted in inconvenient quarters in the wooden annex; while much of the valuable material, to which reference is constantly necessary, is stored in the vastly overcrowded rooms of the National Museum. There is no room in which to rear and study live insects, an important branch of modern entomology, and none worthy the name in which to experiment with remedies and insecticides.

One of the most pressing needs of the division is an exhibition-room, in which to set forth the facts in regard to injurious insects, to display appliances and insecticides needed in subduing them, and to store for ready comparison and study the accumulation of specimens and works of reference which are at the command of the entomologist and his assistants, but now only partially available.

The Bureau of Animal Industry and the divisions of Chemistry and Entomology, in the creation and for the support of which Congress has in other respects provided liberally, have won for themselves a high standing in the scientific world, and it would be a measure of economy now to provide them with the quarters which are absolutely essential to their further development and increased usefulness.

I earnestly beg the attention of Congress to this state of affairs.

PUBLIC HIGHWAYS.

A wise and well-regulated system of public roads and highways throughout the United States is daily becoming a greater necessity for the material development of the resources of this country, and merits the earnest attention of Congress. The common roads of the country are the veins and arteries through which flow the agricultural productions and the commercial supplies, which are the life-blood of the nation, to those great ducts of travel and transportation—the railroads of the country.

While our railway system has become the most perfect in the world, the common roads of the United States have been neglected and are inferior to those of any other civilized country in the world. They are deficient in every necessary qualification that is an attribute to a good road; in direction, in slope, in shape and service, and, most of all, in want of repair. These deficiencies have resulted not only from an ignorance of the true principles of road-making, but also from the varied systems of road-building in force in the several States of the Union, due to defective legislation. The principle upon which the several States have based much of their road legislation is known as the "road-tax" system of personal service and commutation, which is unsound as a principle, unjust in its operations, wasteful in its practice, and unsatisfactory in its results. It is a relic of feudalism borrowed from the "statute labor" of England, and its evil results are to-day apparent in the neglected and ill-conditioned common roads of the country.

It is a question of vast importance to the welfare of this nation that these arteries of agricultural and commercial life should receive the attention that their importance deserves, and that an effort should be made to remedy the defects now existing and establish a system that could be made uniform and efficient in all the States of the Union.

By the improvement of these common roads every branch of our agricultural, commercial, and manufacturing industries would be materially benefited. Every article brought to market would be diminished in price; the number of horses necessary as a motive power would be reduced, and by these and other retrenchments millions of dollars would be annually saved to the public. The expense

of repairing roads and the wear and tear of vehicles and horses would be essentially diminished, and the thousands of acres of land the products of which are now wasted in feeding unnecessary animals in order to carry on this character of transportation would be devoted to the production of food for the inhabitants of the country. In fact, the public and private advantages which would result from effecting this great object in the improvement of our highways are incalculable, not only to the agricultural community as a class, but to the whole population as a nation. The Government itself would be benefited in a reduction of the charge incumbent upon the transportation of its mails where these roads are used as post-roads.

An investigation pertinent to this subject has been inaugurated by the dean of the engineering department of the Vanderbilt University at Nashville, Tenn. He has collected a large amount of data bearing upon the various systems of highway administration, collection of statistics, showing the amounts expended for new roads in each locality, maintenance and repairs of existing roads, length of roads, and the amount of travel on them. This amount of material already collected has been tendered to this Department, if the work would be continued by it and prosecuted to an end. Having no fund available for such an investigation, I have been unable to accept this information upon the terms proposed. I would recommend to Congress that it would be advisable to provide for this investigation to be made so that the outlines of a system could be prepared which would be feasible under our present forms and policies of both general and State government and taxation, to establish a uniform condition of public highways.

PARIS EXPOSITION.

Congress having accepted on the part of this Government the invitation of the French Republic to take part in an International Exposition to be held in Paris in 1889, authorized the Commissioner of Agriculture by joint resolution approved May 10, 1888, to collect and prepare suitable specimens of the agricultural productions of the several States and Territories of the Union for exhibition at said exposition.

A special division has been organized in this Department for this purpose and a number of special agents have been appointed to collect suitable specimens for exhibition. The work incident to the preparation of this exhibit is progressing as rapidly as possible and every effort will be made to prepare a creditable representation of our agricultural productions and which enter so largely into our exports; but the fact that the appropriations for the purpose were made so late is not only to be deplored but will materially affect the exhibition itself.

CORRESPONDENCE.

With each successive year the correspondence of the Department is largely increased, and the variety of subjects on which information is asked more and more diversified, embracing a range far beyond any thing contemplated by its organic act. Such letters as are demanded in arranging the details for the various expositions at home and abroad placed under my charge by Congress, the manifold inquiries relative to the establishment of experiment stations in the different States, the accruing and daily augmenting necessities required in placing the new divisions of Pomology, Ornithology, and Vegetable Pathology, etc., in a condition of usefulness, the information required by proposed emigrants not only as to Territories but also as to newly admitted States, the voluminous details of the recent experiments in the manufacture of sugar from sorghum, and similar leading matters, combined with the ordinary inquiries as to new developments in agricultural machinery, seeds, cereals, etc., have involved an amount of correspondence, which can hardly be inferred from this brief allusion. But the results attained have amply compensated for the increased labor, as evinced by the universal approbation shown in the replies of inquirers, as well as by the fact of the wide distribution of new and important facts which are constantly coming to my notice tending to the promotion of the agricultural interests of the country.

NEW DIRECTORY.

One of the most useful and widely called for reports ever published by the Department was a document issued some years ago setting forth the name and post-office address of the principal officers of each national, State, county, and local agricultural organization or society in the United States.

As the document is now an old one its value has become impaired to a considerable extent, and consequently during the year I have assigned clerks to the duty of collecting as rapidly as possible the necessary data and information to enable us to correct and edit this volume and publish a new directory of the organizations referred to, with a list of their respective officers, brought down to the year 1889.

DOCUMENT ROOM.

The following is a statement showing the number and kinds of documents received at and distributed from the folding-room of the Department. The Annual Report of the Department for 1887 has been printed during the current year by order of Congress, 400,000 copies in number, of which 370,000 are held for distribution by Sena-

tors and members of the House of Representatives, and 30,000 copies assigned to this Department. Other reports have been as follows:

DIVISION OF STATISTICS—NEW SERIES.

	No. of copies.
No. 48. Report upon the numbers and value of farm animals and on freight rates of transportation companies, January and February, 1888	18,000
No. 49. Report on distribution and consumption of corn and wheat and on freight rates of transportation companies, March, 1888	18,000
No. 50. Report of the condition of winter grain and the condition of farm animals and on the freight rates of transportation companies, April, 1888	18,000
No. 51. Report of the condition of winter grain, the progress of cotton planting, and wages of farm labor, May, 1888	18,000
No. 52. Report of acreage of wheat and cotton and condition of cereal crops, with freight rates of transportation companies, June, 1888	18,000
No. 53. Report of the area of corn, potatoes, and tobacco, and condition of growing crops, and on freight rates of transportation companies, July, 1888	18,000
No. 54. Report on the condition of growing crops, and on freight rates of transportation companies, August, 1888	18,000
No. 55. Report on condition of crops in America and Europe, and on freight rates of transportation companies, September, 1888	19,000
No. 56. Report on condition of crops, yield of grain per acre, and on freight rates of transportation companies, October, 1888	18,000
No. 57. Report on yield of crops per acre, and on freight rates of transportation companies, November, 1888	18,000
No. 58. Report on the crops of the year and on freight rates of transportation companies, December, 1888	18,000

BOTANICAL DIVISION.

Bulletin No. 5. Report on the experiments made in 1887 in the treatment of the downy mildew and black-rot of the grape-vine	5,000
Bulletin No. 6. Report on the grasses of the arid districts	10,000
Report of Botanist	500
Circular No. 5. Fungicides or remedies for plant disease	5,000
Bulletin No. 7. Report on black-rot of grapes	10,000

CHEMICAL DIVISION.

Bulletin No. 17. Experiments in the manufacture of sugar at Fort Scott, Kans., Rio Grande, N. J., etc	10,000
Bulletin No. 18. Sugar-producing plants	10,000
Bulletin No. 19. Methods of analysis of commercial fertilizers, etc	3,000

ENTOMOLOGICAL DIVISION.

Bulletin No. 17. The Chinch Bug, April 19	5,000
Reprint of Bulletin No. 9. The Mulberry Silk-Worm, April 30	3,000
Catalogue of Exhibit at New Orleans, May 21	1,000
Reprint of Bulletin No. 10. Our shade trees and their defoliators, July 13	3,000
Author's edition to annual report, July 27	1,600
Reprint of Bulletin No. 9. The Mulberry Silk-Worm, October 29	5,000
Bulletin No. 19. An enumeration of the published synopsis, catalogue of North American insects, October 2	5,000

Insect Life:

	No. of copies.
Volume I, No. 1, July 28	5,000
Volume I, No. 2, August 24	5,000
Volume I, No. 3, October 2	5,000
Volume I, No. 4, October 25	5,000
Volume I, No. 5, November 22	5,000
Volume I, No. 6	5,000

FORESTRY DIVISION.

Bulletin No. 2. Report on the forest condition of the Rocky Mountains, September 29	5,000
Annual report of the division of forestry, August 30	5,000
Circular—increasing the durability of timber	5,000
Circular to Seedmen, on new forage plants	1,000

BUREAU OF ANIMAL INDUSTRY.

Circulars for Bureau of Animal Industry	25,000

ORNITHOLOGIST DIVISION.

Author's edition, September 17	1,500

POMOLOGICAL DIVISION.

Report of Pomologist, September 17	500
Letters of Commissioner of Agriculture in response to Senate resolution of December 7, 1887	1,000

MISCELLANEOUS WORK OF THE FOLDING DIVISION.

Jackets folded	50,000
Envelopes made, 10 by 14	1,000
Franks written	150,000
Number of letters written	300
4,885 packages of envelopes and 2,700 quires of paper mailed to correspondents	7,585

In conclusion, I desire to publicly express my thanks to the officers, employés, and ten thousand correspondents of the Department, for their hearty co-operation in the work of the Department, for their conscientious devotion to duty, for their loyalty to the interests of the present administration of the Department, and in general for the assistance which they have at all times rendered; and, finally, I commend to the consideration of Congress the needs, both present and future, of a Department which, if properly recognized, will become an institution in the public service whose importance and value can not be overestimated.

Very respectfully, your obedient servant,

NORMAN J. COLMAN,
Commissioner of Agriculture.

REPORT OF THE ENTOMOLOGIST.

INTRODUCTION.

SIR: I have the honor to present herewith my annual report for the year 1888. In this report I have carried out the policy outlined in the Introduction to my report for the year 1887, of limiting it to articles of general interest to the whole country and of publishing in special bulletins articles relating to more restricted or local industries.

In pursuance of this policy the leading article in this report treats of the Plum Curculio, an insect upon which nothing complete has been published by the Department, from the fact that I had, previous to my connection therewith, published several extended articles upon it. During the past two years there has been much demand for a general article upon this destructive fruit pest. Much interest has also been excited by the publication of certain articles on the cause of immunity of wild plums, and an important era in the warfare against this insect has been marked by the recent adoption of arsenical sprays as a preventive of injury. Experiments have been carried on during the past two years by agents of this Division which disprove the former theory and which confirm the partial efficacy of a proper spraying with Paris green or London purple. The results are summarized in the article.

The article upon the Hop Plant-louse is a summary of the results arrived at in the investigation. The details of the investigation, together with the reports of agents and some further particulars of the experiments with remedies I have reserved for a special bulletin for circulation among hop-growers, as the paper is too long for the limited space allotted to the annual report.

Since the publication of my report for 1886 a great deal of interesting material has been brought together which is supplementary to the article on the Fluted or Cottony Cushion-scale of California. This matter should be published soon, and inasmuch as the original article appeared in an annual report and as the discussion of remedies is applicable to other scale-insects as well, and particularly as the discussion of some of the principles involved in the study of this pest are of broad interest, I have brought together these supplementary facts in an article in this report. As suggested in the Introduction to my report for 1887, the Department has been able, through the State Department, to send an agent, Mr. Koebele, to Australia, for the purpose of studying and collecting for importation into California the parasites of this pest in its native home. The results of this mission are up to the present time most encouraging. Over 12,000 living parasites have been successfully transported to Los

Angeles, Cal., and are at present confined to infested orange trees under the observation of Mr. Coquillett. I expect two more large shipments and Mr. Koebele will himself return with the last, giving it the most careful personal supervision.

Further experiments with remedies for this scale-insect are detailed in a report by Mr. Coquillett which is published under the head of Reports of Agents. He considers mainly supplementary experiments with the gas treatment and with one of Mr. Koebele's resin compounds. I have elsewhere declared my opinion that the present state of discouragement among citrus-growers of California is not entirely justified, since past experience has shown that by a thorough use of the kerosene-resin washes young groves can be kept free from this scale at a reasonable expense.

A report upon the work in silk-culture is included, from Mr. Philip Walker. In reference to these experiments and to the general subject of silk-culture in the United States I find no reason to modify the conclusions which have been repeatedly expressed in my previous reports. The arguments made some five years ago before the then Tariff Committee in the House of Representatives, which resulted in the recommendation of a duty on the raw silk by the said committee, have the same force to-day that they had then. The duty was stricken off in the Senate by arguments which were humorously in conflict with each other.

For the past five years the Department has been carrying on, under my direction, a series of experiments with a view of testing the feasibility of profitable silk-reeling and of thus establishing a home market for cocoons. For two years these experiments were made at three different points, viz: San Francisco, New Orleans, and Philadelphia, with a view of establishing filatures at such points. The result, as may be seen by previous reports, was not satisfactory. There seemed to be, however, from the promise which the Serrell automatic reeling machinery then gave, some prospect of overcoming many of the difficulties which had been encountered in the earlier attempts, and three years ago Congress authorized you to establish a silk filature in connection with the Department at Washington, where it could be directly superintended by myself and Mr. Walker, and to thoroughly test the Serrell automatic machinery. I felt that two years' experimentation would enable me to give a definite answer to the question as to whether with this machinery the question of labor could be sufficiently minimized to make silk-reeling profitable in the United States.

Owing to various vicissitudes and contingencies which it is not necessary to refer to in detail, and particularly from the fact that experimental work, under Departmental restrictions, is more expensive than it would be in private hands, the results of these two years' experimentation were not entirely satisfactory, though they indicated very clearly that the silk could not be reeled at a profit. Some improvements were at that time being perfected in France in the details of the Serrell automatic machinery which seemed again, according to Mr. Walker, who personally investigated them, to promise well, and to justify the continuation of the experiments; and Congress appropriated the third time for this purpose and also to provide for the establishment of some choking stations at different points in the West or in the centers of silk-culture, where the cocoons might be intelligently handled and choked under supervision.

Owing to the lateness of the season when the appropriation be-

came available; to the fact that the Division was required to make an exhibit at the Cincinnati Exposition; and, lastly, to the fact that Mr. Philip Walker has found difficulty with the later improvements in the machinery received from France, the work the present year has not progressed to such an extent as to justify a final conclusion. Some patentable improvements have been made which may overcome some of the chief difficulties hitherto encountered; but I am free to confess that I have little hope of final favorable result so far as the main object of the experimentation is concerned. In short, I do not believe that, with whatever discoveries or improvements we may make, it will ever be profitable to reel silk in this country without some protection against the cheaper labor of foreign countries, and this means that the experiments so far made confirm the arguments which I have always urged as to the necessity of such protection for the establishment of silk-culture in America.

There is no question as to our ability to produce the cocoon and, as I have urged, we have many advantages over the Old World in this respect; but the five years' experimentation with Congressional aid has simply served to give an artificial impetus to silk-raising which would again fall back to its former condition upon the withdrawal of such aid. No one could be more enthusiastic or more interested in his efforts to successfully solve the problem than Mr. Philip Walker, who has had direct charge of the filature here at Washington; and, after careful calculation, he has estimated that a specific duty of $1 per pound upon the reeled or so-called raw silk would render the reeling profitable in this country. Without such duty I fear that the continued experimentation with the Serrell reel will be of very little avail. For it must not be forgotten that whatever improvements accrue from our own experimentation here will be just as valuable abroad, unless they are protected by patent for the benefit of the American Government.

Without considering in any way the question of protection in the abstract it has always seemed to me plain that if the policy of the Government is protection there should be no exception or discrimination made in this particular case.

The investigations of the Division during the year have been summarized in your annual report to the President. They consist, in brief, of an investigation of the free-living Nematode worms of the family Anguillulidæ which infest the roots of Peach and other crops in Florida; an investigation of the damage done by the Boll Worm of Cotton to the tomato crop in certain of the Gulf States; an investigation of the condition of affairs in the Northwest regarding the probabilities of an invasion of the Rocky Mountain Locust; the further investigation of insects injurious to cereal crops; of the Buffalo Gnat of the Southwest; of certain injurious insects in Missouri, and of insects injurious to live-stock.

The agent who has been engaged upon the first of these investigations has submitted his report, which will be published in a separate bulletin. The report upon the second is here published. The results of Mr. Bruner's trip to the Northwest have been summarized in the September number of the periodical bulletin, and I may here repeat in brief that, so far as his examination of the condition of affairs warrants an opinion, the outlook for 1889 is most favorable. Early in the season the destructive locusts did great damage in Minnesota and excited fears of more widespread injury another year; but this report of Mr. Bruner's and the excellent work done in Minnesota

by a former assistant in the Division, Mr. Otto Lugger, have relieved us from all such anticipations of extended damage.

The publications of the Division during the year represent, to some extent, the work done, and have been as follows:

Bulletin No. 17. The Chinch Bug. A general summary of its history, habits, enemies, and of the remedies to be used against it.

This bulletin was called forth by the fact that the season of 1887 was marked by very extensive Chinch Bug damage over a large portion of the West and Northwest, as well as some of our Southern Atlantic States. It was issued early in the spring and distributed generally over the infested region, affording farmers information upon which to base their operations during the present season.

Bulletin No. 9. The Mulberry Silk-worm. Seventh edition.

The call for this manual of instructions has been so great that six editions have been exhausted.

Bulletin No. 18. The Life and Entomological Work of the late Townend Glover, first Entomologist, U. S. Department of Agriculture.

The work done by Mr. Glover during his long term of service for the Department was of such a character as to merit this attention. In the bulletin the characteristics of the man, his methods of work, and the results accomplished are treated, and a bibliography of his entomological writings is appended.

Catalogue of the Exhibit of Economic Entomology at the New Orleans Exposition. Second edition.

The shape in which this catalogue was published in 1885 was such that it afforded at a glance the principal references to the literature of our most prominent injurious insects, together with an indication of their natural enemies and the remedies to be used against them. Its arrangement was such as to render it an excellent medium for labeling collections in economic entomology, and for conveying succinct information. As a result there has been a constant call for it from entomologists and agriculturists, and a new edition became necessary.

Bulletin No. 10. Our Shade Trees and their Insect Defoliators. Second revised edition.

The call for this bulletin has been very large indeed, and in the light of the experience of the season of 1887, certain facts were added and the second edition was published to meet the demand.

Bulletin No. 19. Enumeration of the published Synopses, Catalogues, and Lists of North American Insects, together with other Information intended to assist the Student of North American Entomology.

Hardly any question is more often asked of the entomologist than how can books be obtained which will enable one to identify insects? This bulletin was published in part to answer this question, and also to furnish information as to the best works upon economic entomology and upon general entomology, and how to obtain them. It has been very well received, and is probably as useful a bulletin as has been published by the Department for some time.

Periodical Bulletin, Insect Life. Nos. 1 to 7.

The necessity for some speedy and regular means of publication, in which might be printed short articles, notes, reports of the progress of investigations, and short articles upon entomological subjects which are either too limited in scope or too disconnected to be used in the annual report or in special bulletins of the Division resulted in

this Periodical Bulletin. The manner in which it has been received, and the favorable comments of the agricultural press, of farmers, and of workers in agricultural entomology, have borne out my prophecy in the introductory number to the effect that so far as the interests of economic entomology are concerned we have instituted no reform that will be productive of more general good or that will give more general satisfaction. The numbers up to the present time have consisted of two signatures each and have been plentifully illustrated, a prominent feature being extracts from the correspondence of the Division with farmers and others on the subject of injurious insects.

The Divisional force remains substantially as it was a year ago, though the demand which the recently established experiment stations have made for experienced entomologists, and the more liberal salaries which many of them are able to pay, as compared with Department salaries, have drawn from the Division two of my effective assistants—Mr. Otto Lugger, who has accepted a position at the Minnesota station, and Mr. William B. Alwood, who has accepted a position at the Virginia station. Their places have been filled by Mr. Tyler Townsend, of Michigan, and Mr. C. L. Marlatt, of Kansas.

The preparation of the exhibit of the agricultural products of the country for the Paris Exposition of 1889, which you have charged me with as your representative, has necessarily occupied much of my time since last September; and as the President has seen fit to appoint me as one of the assistant commissioners to that Exposition I shall necessarily be away from the office for some months during the coming summer. But the divisional force is so organized and plans for the future so made that the work of the Division will not suffer, but will go on under the intelligent management of my first assistant, Mr. Howard, with whom I shall be in constant correspondence during my absence.

Respectfully submitted, January 31, 1889.

C. V. RILEY,
Entomologist.

Hon. NORMAN J. COLMAN,
Commissioner.

MISCELLANEOUS INSECTS.

THE PLUM CURCULIO.

(*Conotrachelus nenuphar*, Herbst.)

Order COLEOPTERA; family CURCULIONIDÆ.

By C. V. RILEY and L. O. HOWARD.

[Plates I and XII.]

INTRODUCTORY.

In the last annual report considerable space was devoted to the reconsideration of two of our injurious insects of first importance which had been attracting much attention, but concerning which there had been no comprehensive account published by the Division. In the

same way we this year review once more, for the purpose of placing it in readily accessible shape, the habits and life-history of the well-known pest whose name appears at the head of this article. Since the publication of the entomological reports of Missouri, although the newspaper literature has been very extensive, no one comprehensive article of much detail has been published, so that we propose here to give, without much circumlocution, the exact facts ascertained, and to devote some little space to the treatment of remedies.

GEOGRAPHICAL DISTRIBUTION.

The genus Conotrachelus is almost exclusively American. Of something over a hundred species which have been described, all are either from North America, Mexico, Central America, the West Indies, or South America, with the exception of *C. helferi,* said to come from East India, *C. hirsutus* and *C. hispidus*, which were described from the island of Lifu (South Pacific), and *C. tagax,* supposed to come from Caffraria. There is some doubt as to the correct generic reference of the first three species, and the locality of the last has been questioned. North America alone contains twenty-eight species. The Plum Curculio proper (*C. nenuphar*) is confined, so far as we can learn, to the United States, and was first described in 1797 by Herbst, and was redescribed by Fabricius and Dejean under different names. It was treated as an insect pest at least as early as 1746, and there is no doubt whatsoever that it is an indigenous species, feeding in this country upon wild stone fruits from time immemorial. It seems certain, moreover, that from the very first it has not been confined to any one section of the country but has existed wherever wild plums grew. It seems tolerably certain also that the insect has increased enormously in parts where cultivated varieties have been introduced, and its comparative scarcity where only wild fruits grew years ago has frequently given rise to the idea that it was actually introduced with the cultivated varieties; whereas it furnishes simply another case of the preference of an indigenous insect for introduced and cultivated plants congeneric with, or allied to, its original food plant, with instances of which every student of economic entomology is so familiar. We need only mention the case of the Colorado Potato-beetle to furnish at once a striking example.

At present the Plum Curculio is known from Canada to Florida and west to the Rocky Mountains as a stone-fruit destroyer. It has not been found as yet, so far as we know, in California or elsewhere on the Pacific coast, and such collectors as Mr. James Behrens, Dr. J. J. Rivers, and our agents, Mr. D. W. Coquillett and Mr. Albert Koebele, have never collected it west of the Rocky Mountains. Its appearance on the Western slope, however, is probably only a question of time, when the intervening country becomes more thickly settled, although it is interesting to note that twenty-two years ago Mr. Walsh commented upon the non-occurrence of the pest in California, but did not predict its eventual introduction, because of the different character of the fauna and flora of the Pacific coast. While there has always been some danger of the introduction of the pest into northern California, Oregon, and Washington Territory, we think that the fruit-growers of southern California have little to fear, as we have observed that long dry spells usually destroy the pupæ in the ground. We therefore doubt whether it could successfully bridge over the long dry seasons which are there so prevalent.

FOOD PLANTS.

The Plum Curculio has brought about an almost entire abandonment of plum culture in many sections of the country within the last twenty years; but it is by no means confined to this fruit. It breeds in great numbers in cherries, peaches, apricots, nectarines, and other stone fruits, including the Persimmon, and also infests many varieties of apples, crabs, and haws. It prefers, however, smooth-skinned fruits. It is also a common inhabitant of the fungus growth of Plum and Cherry known as "Black Knot" (*Plowrightia morbosa*), from which it was first reared by Peck in 1818.

It was at one time thought that this species bred in green butternuts and walnuts, making the same crescent-shaped mark in the outer skin of the nuts. Fitch noticed the insect upon Butternut, and recorded the fact that specimens so found were larger than the plum-fed individuals. Walsh afterward bred the beetles from these nuts and sent specimens to LeConte, who considered them as belonging to a phytophagic variety of the plum species, differing only in size. Walsh later pointed out a constant colorational difference, and LeConte subsequently established a distinct species (*Conotrachelus juglandis*) for the nut-bred form.

HABITS AND NATURAL HISTORY.

The Egg and the Process of Oviposition.—The egg of the Plum Curculio is oval, of a pearl-white color, and large enough to be seen with the naked eye. Careful measurements indicate that the average length is about 1^{mm}. It is laid in green fruit soon after the blossoms fall. The number of eggs laid by a single female has been variously stated. Riley, in 1868, estimated from fifty to one hundred, which are laid at the average rate of five to ten per day. Prof. A. J. Cook, in writing to the New York Weekly Tribune of June 9, 1880, says, "I know by dissection that a single female may contain thirty eggs." Dissections made for us during the season of 1887, by Mr. Alwood, showed that early in May only one or two fully developed eggs could be found; many immature ova, however, could be seen. Late in May, however, from four to ten mature eggs were found in each female examined. No account of the actual number of eggs in an ovary at any one time was made, but from what we know of the rate of development Riley's estimate, based on dissection and observation, is unquestionably correct.

The process of depositing a single egg requires about five minutes. The description of the process published by Riley may be repeated: "Having taken a strong hold on the fruit the female makes a minute cut with the jaws, which are at the end of her snout, just through the skin of the fruit, and then runs the snout under the skin to the depth of one-sixteenth of an inch, and moves it back and forth until the cavity is large enough to receive the egg it is to retain. She next changes her position, and drops an egg into the mouth of the cut; then, veering round again, she pushes it by means of her snout to the end of the passage, and afterward cuts the crescent in front of the hole so as to undermine the egg and leave it in a sort of flap; her object apparently being to deaden this flap so as to prevent the growing fruit from crushing the egg, though Dr. Hull informs me that he has repeatedly removed the insect as soon as the egg was deposited and before the flap was made, and the egg hatched and the young

penetrated the fruit in every instance." Many subsequent observations both under cover and in the field, made for us by Mr. Alwood, confirm the above. When he was able to time the operation, however, it required a longer period than that mentioned by Riley. The first cutting of the cylindrical hole occupied five minutes, the depositing of the egg thirty seconds, and the packing in of the egg and the cutting of the crescent slit from six to eight minutes longer. The time occupied varies, however, with the temperature and the vitality of the individual. In cutting the crescent the snout is swung to one side as far as the joint between the head and pro-thorax will permit, and is inserted into the fruit at an angle of about 45 degrees and directed backward under the body. The cut is continued around the egg-puncture as a center as far as the head will turn, and as far as the snout will conveniently reach. The resulting slit is therefore an arc of a circle. The object of the cutting of the crescent slit was first suggested by Mr. Franklin C. Hill, of Yellow Springs, Ohio, in the *Practical Entomologist*, Vol. II, p. 115 (September, 1867). After describing the operation, Mr. Hill says: "Can her object be to wilt the piece around the egg and prevent the growing fruit from crushing it?" Walsh and others immediately accepted this explanation, which is undoubtedly the correct one. Previous writers, including Walsh himself, followed Harris, who expresses himself on this point as follows: "The beetle first makes a small crescent-shaped incision, with its snout, in the skin of the plum, and then, turning round, inserts an egg in the wound." The eggs will hatch in from three to ten days, depending upon the weather, and, as the period of oviposition frequently extends over two months, a confusion of stages arises.

From Riley's observations it seems quite certain that many of the eggs which are deposited after the 1st of July fail to hatch, or the young larvæ die soon after hatching, owing in all probability to the riper and more juicy condition of the fruit at that season. A number of eggs may be deposited in a single plum, whether by the same female or not has not been determined. From one to a dozen of the crescent marks are often seen upon a single plum, while a single apple may carry a greater number.

The Larva.—The larva of the Plum Curculio is white and footless, and furnished with a horny head (Plate I, fig. 1). It works its way immediately after hatching in stone fruit to the pit and there grows to full size, eating the pulp around the stone. The larva attains its full growth in from three to five weeks, when it is about 10^{mm} (0.4 inch) in length, rather stout, and of a glistening whitish color. The head is light brown and there is a pale line along each side of the body. There is a row of small black bristles below the side lines and on the second segment a less distinct row of bristles above; also a few pale hairs near the anal end of the body. The fruit thus infested falls prematurely in a large majority of cases with plums, apricots, and peaches. Cherries, however, do not fall, but remain upon the tree. One or two varieties, particularly the English Morello, are said, however, to mature and drop. In cherries seldom more than one larva is found in a single fruit, but several are often found in a single plum, peach, or apple. Rarely are as many larvæ found in the fruit as there are punctures under the skin, and many eggs therefore fail to hatch.

After the fruit has fallen to the ground the larvæ may still remain within it for some time, but as soon as they are full grown they issue and enter the ground to pupate. Larvæ issuing from cherries drop to the ground for the same purpose. They seldom burrow to a

greater depth than 4 or 5 inches, and at the end of the burrow they construct a small oval cell within which to pupate.

Pupa.—The pupa is illustrated at Plate I, figs. 2 and 3. It is white at first, becoming yellowish as it grows older. It remains in this condition from three to six weeks.

The Adult.—The beetle is familiar to most fruit-growers and is besides so well shown at Plate I, figs. 4, 5, and 6, that a detailed description is unnecessary. While the females lay their eggs chiefly during day-time the insect is essentially nocturnal, flying freely during the warmer nights and only seeking shelter when the nights are cold.

There has been much discussion upon the point as to how much the insect feeds in the adult state, as the question is important from a remedial stand-point. There is no longer any question about the matter, however, for Riley records the fact that the adult gnaws not only the fruit but also the young twigs and even the buds and leaves for food, both in the spring and in the late summer. The holes in the young plums made by feeding are irregular, and need never be mistaken for the marks made by oviposition. Fig. 8 of Plate I will indicate the size and shape of some of these food scars. The normal feeding spot is, however, not so large as the largest ones there indicated and is usually circular. This taking of food by the adults is mainly noticeable in the spring, as the fruit and vegetation is at that time smaller and younger and the beetles after their winter fast may be presumed to be hungrier. Some further observations upon the feeding habit in autumn have only recently been recorded by Prof. J. H. Comstock, who proved that this Curculio is responsible for at least some of the numerous circular pits seen in apples in late summer and early fall, and has recorded his observations in the American Naturalist for November, 1888, pp. 1035 and 1036, under the caption "Serious injury to apples by the Plum Curculio." We quote from his article as follows:

> During the latter part of the past summer my attention was attracted to a serious injury done to the fruit in an apple orchard through which I passed daily. A large proportion of the apples in a corner of the orchard had been eaten into by something which made small pits from one-eighth to one-fourth inch in diameter, and of about the same depth. On one tree nearly every apple had been attacked, and in many cases there were ten or twelve holes in a single apple. The injury was so serious as to render fruit on this part of the orchard unmarketable.
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> The holes in the apples were first discovered during the latter part of August. At that time many of them were partially grown over, while others were fresh, indicating that the pest had been at work for a considerable time and was still active. As the injury to the apples resembles somewhat that caused by a climbing cut-worm that sometimes infests apples of western New York, I at first searched for caterpillars, and gave little thought to the plum curculios that I frequently found hiding in the pits in the apples. But, after finding a considerable number of the insects in these pits, it occurred to me that they might be the cause of the mischief. Several perfect apples were then selected and placed in breeding cages, in each of which were confined several curculios. The question was soon settled. Within twenty-four hours the beetles had begun to eat into the apples. They made small holes at first, but these were soon enlarged so as to form pits of the size indicated above.
> * * *

The substance of this note was reprinted in Bulletin 3 of the Agricultural Experiment Station at Cornell University, together with advance quotations from a then unpublished note by Mr. C. M. Weed, entomologist to the Ohio Agricultural Experiment Station, in which Mr. Weed states that he was surprised to notice the avidity with which an adult Curculio ate a large green plum when confined with it in a

breeding jar in June. He also states that he has been informed by Professor Forbes that he has found that the adult Curculio eats freely of the substance of the leaves. All these late observations confirm and recall similar experience by the senior author years ago in Missouri.

Number of Broods and Hibernation.—About these two points there has been much confusion among the earlier writers on this insect. Dr. Harris and previous writers believed that the winter was passed in the larva state under ground. Dr. E. Sanborn, in 1849, stated that in his opinion the insect hibernates in the beetle state above ground. Dr. Fitch concluded that the insect was two-brooded, the second brood wintering in the larva state in the twigs of pear trees, while Dr. Trimble, in his "Insect Enemies of Fruit and Fruit Trees," concluded that it was single-brooded and hibernated in the beetle form above ground. Dr. Trimble's conclusions, which subsequent observations and experiments have proved to be correct, were accepted by later authorities, prominent among whom were Walsh and Riley. The latter, however, in 1867, published an anonymous article in the Prairie Farmer for July of that year, over the signature of "V," in which he concluded from the early appearance of adults near Cobden that the insect was, exceptionally, two-brooded, or that it was more frequently two-brooded in the region of Cobden. This communication Mr. Walsh quoted as corroborative of his revised opinion, and in his first report as acting State entomologist of Illinois, submitted in 1867, entered into an extended argument to prove that the insect is two-brooded, based almost entirely upon the fact that from a lot of plums placed by him in breeding jars the adults issued steadily from July 19 to August 4, and that there was then a period from August 5 to August 22, inclusive, during which no beetles appeared, although on August 25 they commenced appearing again and continued to do so daily until September 14. His inference was that the beetles of the latter series were the offspring of those of the former. The flaw in his argument comes from the fact that the beetles of the two series were from two distinct lots of plums, collected at different times, the first series issuing from plums collected June 24 to 27, from both wild and tame trees, while the plums from which the second series issued were not collected until July 27 and were exclusively from wild trees.

Dr. E. S. Hull, in 1868, from his own personal experience corroborated the views announced by Dr. Trimble, and in the same year Riley, in his First Report on the Insects of Missouri, accepted these conclusions in large part, with the reservation, however, that a certain portion of the insects might pass the winter under ground both in the larva and pupa states at a depth frequently of from 2 to 3 feet. (Walsh had previously accepted the hypothesis of the hibernation in the adult state only.) In his Third Report, however, Riley fully corroborates Dr. Trimble's conclusions. He conducted extensive and careful experiments which settled the question of the insect's single-broodedness, and he satisfied himself that it invariably passes the winter as a beetle under all sorts of shelter in the woods, generally, however, near the surface of the ground. Indeed, he states that it often makes for itself a hole in the ground, seldom, however, deep enough to more than cover its own body.

The principal reasons for the misconception as to number of broods are found in the fact that an allied species (*Conotrachelus crataegi*) hibernates in the ground in the larva state and that many adults of *nenuphar* issue from stung fruit remarkably early in the season and

remain alive until the following spring before ovipositing. Riley, in his Third Report, mentions individuals which issued from the first peaches the latter part of June and which he had alive at the time of writing (December 2). He also in this report called attention to the fact that the adult insects often make a peculiar creaking noise by rubbing the tip of the abdomen up and down against the wing-covers.

NATURAL ENEMIES.

Birds.—Mr. Trimble was probably the first to record the fact that the Baltimore Oriole will feed upon this insect, and subsequent observation has confirmed it. Poultry of all kinds will devour the Curculio and serve to protect from injury trees growing in ground which they frequent.

Predaceous Insects.—The following predaceous insects have been observed to feed upon the Curculio in one or the other of its stages: The Pennsylvania Soldier-beetle (*Chauliognathus pennsylvanicus*) in its larva state is one of the most effectual destroyers of the Curculio larva within the fruit, whether while this hangs on the trees or after it has fallen to the ground. One of the Golden-eyed Lace-wing Flies (*Chrysopa*) and two Ground-beetles known as *Aspidiglossa subangulata* and *Harpalus pennsylvanicus* have also been observed to feed upon the larva. [See Plate XII, figs. 1 to 5.]

True Parasites.—The first known parasite of the Plum Curculio was the Braconid (*Sigalphus curculionis*, Fitch) described originally in 1861, from specimens bred from Black-knot by Mr. D. W. Beedle, of St. Catherine, Canada West. Fitch considered this insect to be parasitic upon the Curculio, but there was no positive proof until 1871, when Riley reared a large number from Curculio larvæ. Fitch's conclusion had meanwhile been contradicted by other entomologists, and principally by Mr. Walsh, who, in his report as acting State entomologist of Illinois, endeavored to show that the Sigalphus was parasitic instead upon the larvæ of the little Plum Moth, *Semasia prunivora.* Riley's observations upon this parasite were very complete. He half filled large jars with pure earth finely sifted, so that no living animal was left in it. Into these jars he placed from day to day Curculio larvæ as they issued from peaches, and in due time the parasitic flies began to issue from the ground along with the perfect Curculios. He learned to distinguish the parasitized individuals, and was enabled to watch the parasitic larvæ reduce its victim until nothing was left. After the Curculio larva is destroyed the parasitic larva incloses itself in a tough yellowish cocoon and assumes the pupa state, emerging with the adult Curculios. During 1871 Riley states that three-fourths of the more early developed Curculio larvæ were destroyed by this parasite in the vicinity of Saint Louis. In that season he reared and distributed a large number of these parasites in different parts of Missouri. This was the same season that Dr. Le Baron experimented in transporting the Aphelinus parasitic on the Oyster-shell Bark-louse of the Apple, and the two are the first experiments of the kind recorded as far as we know. Walsh bred what he considered to be this same parasite from the Plum Moth, and indeed the genus Sigalphus is not one in which we notice any striking uniformity of habit. The species which have been reared in Europe attack indiscriminately Tineid moths and bark or wood boring beetles, so far as observed.

The second parasite was originally described by Riley in 1871 as

Porizon conotracheli, and reared from cocoons sent to him by Dr. Trimble. The species is now placed in the genus Thersilochus, a genus which is closely allied to Porizon and distinguished by comparatively unimportant characters. This insect works in very much the same way as the one first mentioned, but instead of issuing as an adult the same season it remains in its tougher and somewhat darker cocoon through the fall and winter, issuing only the following spring. This parasite seems to be nearly as abundant in certain sections of the country as the Sigalphus, and probably both are of some assistance to fruit-growers. The habits of other species of the genus Thersilochus do not seem to be known, but its close ally, Porizon, is well known as parasitic upon beetle larvæ in Europe. One species has also been reared from Rose galls; but here it may also be parasitic upon some inquilinous beetle. Strange as it may seem, we have recently received specimens of the Thersilochus, which were sent to us as new and destructive enemies to plums. They were captured in the act of laying their eggs in the fruit, and the correspondent asked us whether they they were not the parents of the white worms so often found in plums and cherries! For figures of these two parasites see Plate XII, figs. 6 to 8.

REMEDIES.

For nearly a hundred years the agricultural and horticultural papers of this country have been flooded with articles upon the Plum Curculio and particularly upon remedies for its injuries, and very little progress has been made in this direction for many years until quite recently. In 1807 Dr. James Tilton, of Wilmington, Del., presented a paper to the Philadelphia Society for Promoting Agriculture, in which he cited many of the best-known remedies which have since been elaborated and worked over and improved upon to some extent. This paper really contains the germ of all that is now known concerning the remedies for this insect. For no other insect, perhaps, have so many fallacious and even ludicrous remedies been proposed, and it is difficult to see why this should be the case, as the life-history of the insect was known with some degree of certainty as early as the date we have mentioned.

Preventives.—Under this head we may mention the use of bands around the trunk of the tree; smudges of gas-tar and other substances; the placing of strongly odoriferous substances in the tree, such as coal-tar, camphor, ethers, carbolic acid, etc.; and the dusting or spraying of the leaves and fruits with repellents, such as lime, soot, ashes, salt and water, etc.; the planting of trees over water-courses or small ponds; the use of pavements under the trees; heavy manuring under the trees; and, finally, the planting of plum trees among other fruits. None of these methods are of much avail as preventives, although some of them may be of slight effect as direct remedies.

The practice of using bands of wool, cotton, or some adhesive is, in the main, the result of the supposition that the female curculio can not fly. This is of course entirely erroneous, yet it is an error which is continually occurring in print.

Adhesives painted on the bark of the tree and kept fresh will catch an occasional curculio, but many of the substances recommended for this purpose are absolutely dangerous to the life of the tree, and the wool bands are in reality a convenience for the beetles, as they will use them to some extent for shelter during cold nights.

The application of ill-smelling substances to the plant and the use of smudges are based on the idea that the insect will be deterred from oviposition by the odors. Both experiment and our own observation have shown that coal-tar and other malodorants do not repel in this case, and it is extremely doubtful if enough good was ever accomplished by their use to pay for the trouble and expense. Mr. Lintner, as recently as 1882, in his paper on the "New Principle in Protection from Insect Attack," devotes considerable space to this idea. This paper in the main is devoted to proving what is generally admitted, that insects possess a sense of smell, while he cites no actual experience or observations in support of the practical value of repellents. Theoretically, this remedy seems valuable, and unquestionably there have been instances in which immunity from the Curculio *seemed* to have been produced by repellents; but in all cases which have come to our knowledge careful inquiry developed other causes.

With regard to the dusting of lime saturated with carbolic acid upon the trees, a remedy which has been recommended in more than one article upon the subject, we may state that we have had it thoroughly tested by Mr. Alwood, without beneficial effects. A heavy lime-wash has been shown to be to some extent a protection, but its application with sufficient care to be a good preventive would really amount to coating every plum with the wash.

The planting of trees over water resulted from the idea that the instinct of the female beetle would deter her from laying her eggs in situations where her offspring would be likely to perish, but this idea has proved to be fallacious in practice, as the beetles will oviposit as freely in plums in such situations as in any other. This, however, as a direct remedy is unquestionably of some avail, as the stung fruit dropping in the water causes the death of the contained larvæ in perhaps the great majority of them, and where no other fruit occurs in the immediate vicinity much good may result to the particular trees. It is practised to the present day by Admiral Ammen, of Ammendale, Md., near Washington.

Dr. Tilton, in the paper previously mentioned, suggests the use of pavements under plum trees, without, however, giving his reasons. The same idea was proposed fifty years later and created a great deal of discussion, and a particular kind of pavement was invented by the Hon. James Matthews, and his invention was investigated by a committee from the New York Agricultural Society, and by the editor of the *Country Gentleman*, with a view of securing for the inventor a recompense for the remedy should it prove successful. Nothing, however, came of it and the whole matter was dropped. Mr. N. Longworth, of Cincinnati, Ohio, wrote a great deal at this time in support of this remedy, and his idea was that the "safety of the pavement arose from the instinct of the insect. It will rarely deposit its eggs over a pavement, as the young, when they fall from the tree, can not secure winter quarters in the earth. The mother feels too strong an interest in the children to subject them to such a fate." The idea arose undoubtedly from the fact that such pavements occur naturally only where they are continually walked over, and the comparative immunity of such trees is due as much to disturbance and motions of pedestrians, which the Curculio avoids, as to the fact that the trees are not restocked from insects which have bred upon them.

The protection of what are called garden plums from injury by interspersing them with native plums has received considerable notice lately, and chiefly through Mr. D. B. Wier, formerly of Lacon, Ill., a well-known fruit-grower and writer. Mr. Wier argues this matter at considerable length in Bulletin 14 of this Dvision, and has since, in his private communications, sent us considerable confirmatory testimony from other fruit-growers. Adverse testimony, however, is not wanting, as will be shown later. Mr. Wier's experience, however, is so extensive, and his facilities for observation are so great, that it is only to be regretted that neither in this bulletin nor elsewhere has he published exact data upon which a clear, exact, scientific statement can be based. Fallacies in his argument are pointed out by Riley in the introduction to the bulletin mentioned and in foot-notes. We consider Mr. Wier's thesis as unproven, and simply mention it here in its proper place, as it receives fuller treatment at the end of the article.

Direct Remedies.—Under this head we shall discuss all measures for entrapping or capturing, by jarring as well as poisoning, the parent insect and all measures designed to destroy the larvæ. The direct remedies have all been summed up by Riley in his Missouri Reports. The one advance which has been made since their publication is, perhaps, the application of arsenical poisons to the tree, with the idea of killing the beetle while feeding. This is considered at the end of the other remedies.

Trapping.—Trapping the beetles when they first appear in the spring by clearing all miscellaneous rubbish from under the trees and placing chips, bits of boards, or anything easily handled which will afford them shelter, has been quite extensively practiced. This was at one time proclaimed by Mr. Ransom, of Saint Joseph, Mo., and others, as the great remedy which was surely to exterminate the Curculio. It is mentioned in Riley's reports as "the Ransom chip-trap process." The earliest recorded mention of this remedy noted by Riley is in Moore's *Rural New Yorker* for January 28, 1865, in a communication from Mrs. H. Wier, of Johnsonville, N. Y. Riley visited Mr. Ransom at Saint Joseph for the purpose of examining more closely into this Curculio remedy and found that, while with unusual perseverance and great care in setting his traps Mr. Ransom captured a great number of Curculios, yet at the same time, even under his trees, a number of stung and fallen fruit indicated "too plainly that there is no hope of extermination by the chip plan alone." The successful use of this remedy is governed almost entirely by the temperature. So long as the nights are cool a certain proportion of the beetles will find their way under the traps, but as the nights grow warmer the number will dwindle greatly. Under this head we may quote a little table prepared by Dr. E. S. Hull, of Alton, Ill., and showing the results of the chip-trap process in comparison with the jarring method to be treated in the next section, the "Curculio catcher" invented by himself being used for the jarring:*

When we arrived at home from our Michigan trip, Curculios had been at work in our grounds about twenty-five days. We were, on that account, at least that number of days too late to fairly test the value of Mr. Ransom's discovery for this latitude. But that we might know with respect to its merits in our warmer climate, as a means of exterminating or capturing such Curculios as yet remained in the orchard, or those which came in from the forest or surrounding orchards, we at once selected five of our largest Nectarine trees in fruit.

*See Trans. Ill. State Hort. Soc., 1870, pp. 228–229.

The trees we selected were those most exposed to insects coming in from other points. The necessary preparation of the ground was made, by removing all rubbish under which the insects could secrete themselves, and by perfectly leveling and smoothing the earth under the trees, and especially around the stem of the trees, so as to leave no lumps of earth, or cracks, or crevices under or in which a Curculio could secrete itself. This done, we surrounded the stem or trunk of each tree with corn-cobs, pieces of bark, etc., placing these so the edges next to the trees should touch the trunks, and pressed them down gently into the earth so as to leave only small openings under them into which the insects could enter.

Now for results:

May	29.	Curculios taken under trap	0
	29.	On Curculio catcher	63
	31.	Taken under traps	0
	31.	On Curculio catcher	38
	31.	Cloudy and rainy a little.	
	31.	Under traps, Plum Curculio	2
	31.	Under traps, Apple Curculio	3
	31.	On Curculio catcher	41
June	1.	Taken under traps, Apple Curculio	3
	1.	Plum Curculios, on Curculio catcher	58
	1.	On two corn-cobs, laid together in forks of tree	1
	2.	Taken under traps, Plum Curculio	1
	2.	Apple	4
	2.	On Curculio catcher	109

The catcher was run about 7 o'clock each morning, and the traps were examined at 5, at noon, and again between 6 and 7 each evening.

Jarring.—Jarring the trees to catch the beetles is one of the oldest direct remedies known. It is founded upon the habit which the beetles have when alarmed, of folding their legs and dropping from the tree as if dead. In the article by Dr. Tilton, previously referred to, is a statement of the manner in which this remedy was first discovered, and as the article seems to have been unfamiliar to later writers we consider it worth repeating. "Besides, the Curculio is very timid, and when frightened by the cattle rubbing against the tree or otherwise, their manner is to fold themselves up in a little ball and fall to the ground, where they may be trampled and devoured by the stock, poultry, etc. Col. T. Forest, of Germantown, having a fine plum tree near his pump, tied a rope from the tree to his pump handle, so that the tree was gently agitated every time there was occasion to pump water. The consequence was that the fruit of this tree was preserved in the greatest perfection." This indicates that the jarring remedy was known at least prior to 1807, and it has continued until the present time to be one of the best remedies known. In 1832 Mr. David Thomas published a statement in the *Genesee Farmer* (Vol. II, pp. 155, 156, June 7, 1832) describing the capture of Curculios by shaking the trees and catching them on sheets kept exclusively for the purpose as "commonly practiced." Three days afterwards he published the statement that *jarring* the tree was the more efficacious. In the *Cultivator* for August, 1851, he gives in detail his method of procedure, stating that he had adopted the plan of striking a short stump of the sawed-off limb with an ax. He advises that the striking be done in the cool of the morning. Dr. I. P. Trimble, in his "Insect Enemies of Fruit and Fruit Trees," published in 1865, gives a lengthy account of his experiences, and says that the only safe and effective method is jarring. He used a large sheet spread open by a large stick at each end and with a slit of half its length. He jarred each limb separately with a padded mop-stock. Dr. E. S. Hull, of Alton, Ill., in 1868 and 1869, brought the jarring method into popular notice by a patented device for jarring the trees and catching the beetles. This was a great hopper-like canvas ar-

ranged on a long-handled wheelbarrow. The canvas was slit in front to admit the body of the tree, and the hopper had a heavy piece of timber over the wheel, which was to butt against the tree. This device was rude but rather successful, and from it several others were developed, the most successful of which are, perhaps, the ones made by S. M. Ward, of Benton Harbor, Mich., and a very similar one by the Brown Brothers, large plum-growers, near Norwalk, Ohio. They differed from Dr. Hull's apparatus in being mounted upon two wheels. The hopper of the Brown machine is of canvas, and they both have boxes at the bottom into which the Curculios roll when they are jarred down. This box is opened and closed at pleasure by a lever, and is certainly an improvement on the plan of mashing the beetles after jarring each tree, as the box can be removed and the beetles crushed by wholesale when necessary. In the *Ohio Farmer* for February 17, 1875, it is stated that one man jarred 1,400 trees in eight hours with the Brown machine, and that three men jarred 2,000 trees twice a day. Mr. Ward used a mallet for striking the tree and the Browns used a long stick with a crook which was hooked over the long limbs and quickly jerked.

The addition of two wheels to the machine was undoubtedly an improvement, and the jarring of the trees with a mallet or crooked cane, of course, can be more successfully done than with a bumping arrangement upon the barrow.

The early method of using a sheet spread upon the ground, mentioned by Mr. Thomas in 1831, is, with slight modifications, in use to-day, and some of the best growers desire nothing better than a muslin canvas carried by hand and a mallet to jar the trees.

The simplest possible canvas is made by cutting strips of ordinary heavy muslin 8 or 10 feet long or according to size of tree, and sewing together four, six, or more widths as may be needed, leaving the central seam open to the middle of the canvas. This is easily drawn around the tree and answers every purpose. It will stay in place better if a light rod or bar is fastened along two sides. But the form of canvas which Mr. J. J. Thomas considers best suited for this purpose is a piece of heavy muslin sufficiently large for one side of a tree, along the longer edges of which are fastened light rods, and at the middle a cross-bar a little shorter than the width of the muslin. This permits a slight sag in the cloth which facilitates capturing the beetles as they will thus roll together. This is carried on one arm by means of the cross-bar above mentioned, and the tree is jarred by the use of a mallet carried in the other hand. With this canvas but half of the tree is jarred at a time, and passing up the other side of the row the work is repeated.

There can be no doubt but practical use has demonstrated that the jarring method is the most effective way yet proposed for destroying these insects. As to the form of apparatus used, it is simply a question of the amount of work to be performed and the desires of the operator. The old-fashioned method of jarring onto canvas spread on the ground is quite objectionable because it is slower, and the canvas soon becomes wet and soiled if the ground is damp, which it very often is. For rapid work with two men, we could suggest no better cheap apparatus than two frames such as Mr. Thomas uses, and then have the two men take opposite sides of a row and jar both sides simultaneously. We think that the results would be better in this way than where one side is jarred at a time, as by the latter method doubtless some must escape.

A very great improvement on this canvas would be some convenient pocket or receptacle at the center, holding several quarts, into which the beetles could be brushed and confined until a large number had been caught; then all could be crushed on some hard, smooth surface, with a saving of time and in a manner more pleasant than the use of thumb and finger.

Jarring with a mallet is a very successful method of bringing down the beetles if properly done. The two methods most common are to saw off a limb (or two limbs if the tree is large) at convenient points for striking with a mallet, or to insert a small iron pin, three-eighths to one-half an inch in diameter, into the body up near the limbs or into a couple of the larger limbs where the trees are large. These should be about 3 inches long and inserted half their length. If a limb is sawed off it should be cut about $1\frac{1}{2}$ or 2 inches from the body, and the edges jarred off so as to leave a conical surface to strike upon. Either of these methods can be employed with little or no injury to the tree. The time of jarring is a matter of some importance, though in large orchards it is sometimes carried on all day. We believe that where orchards can be gone over in an hour or so it should be done both morning and evening.

It is quite uncertain whether more Curculios will be caught at one time or another, but at these times they will lie more quietly on the canvas than in the middle of the day and jarring but once a day certainly gives the beetles a pretty good chance to oviposit in a large percentage of the fruit.

The destruction of the larvæ in fallen fruit before they have escaped into the ground is a most important part of any rational system of dealing with this pest and can best be done by gathering and feeding all fallen fruit to the hogs, or better still, allowing them to gather it themselves, where this can be done without injury to other crops. The larvæ usually have not escaped from the cherries when they are gathered (these seldom ever fall when infested), but plums and apples will in the majority of cases fall before the larvæ have escaped. We have before mentioned the fondness which poultry have for the Curculio in all its stages, and it should be here again stated that experience has shown that where plum trees grow in a poultry yard, or where the plum orchard can be inclosed by a picket fence and poultry be allowed to run loose, the crop of fruit will almost invariably be a good one. Mr. P. B. Follansbee, of Andover, Mass., is said to have the largest nursery in that vicinity, and to have always a crop of perfect plums, through following this method. Other correspondents indorse this plan, and we notice a particularly enthusiastic indorsement of it from Adams Rockwood, of Worcester County, Mass., in *Farm and Home* for September 1, 1887.

Spraying with arsenical Mixtures.—Testimony as to the efficacy of this remedy is variable, but theoretically it is a sound one, and such experiments as have been made indicate that it will pay to spray trees for this purpose. It is difficult to properly credit the first suggestion of this remedy, but it is certainly not so recent an idea as is generally supposed. In 1871 it was recommended by Mr. G. M. Smith, of Berlin, Wis., to the Saint Joseph (Mich.) Horticultural Society, and from that time on has been occasionally suggested in newspapers. Both entomologists and the more prominent horticulturists, however, were for a long time inclined to discredit its efficacy. Mr. J. Luther Bowers, of Herndon, Va., informs us in conversation that in the summer of 1880, while he was living in Clarke County,

Va., he sprayed his plum trees with Paris green in the proportion of 1 tablespoonful of the green to 5 gallons of water, using for the spraying a Whitman fountain pump. He sprayed soon after the petals fell and again in a week or ten days. The result was the most perfect crop of plums he had ever grown. He removed to California at the close of the season but did not repeat his experiment, and for that reason the remedy did not gain circulation at that time. From 1884 on the use of arsenicals for the Curculio assumed a more important aspect. Mr. William Creed, of Rochester, in the August (1884) number of Purdy's *Fruit Recorder*, gave in general the results of a favorable experience with Paris green against this insect, and in the November (1885) issue of the same journal recorded the complete success of the remedy. Riley, in an address delivered before the Mississippi Valley Horticultural Society, in the early spring of 1885, at New Orleans, in giving his experience as to the feeding habits of the beetle, urged experimentation with the arsenicals in this direction as promising fair results, though in the very nature of the case not as satisfactory as in the case of the Codling Moth. During the summer of the same year Professor Forbes began a series of experiments in Illinois. In the article upon the Codling Moth, published in our annual report for 1887, Mr. Howard has given in full Professor Forbes's table in which the effects of Paris green and London purple upon the Plum and Apple Curculios are given in connection with their effect upon the Codling Moth. It must be remembered, however, that his experiments were made entirely upon apples. He shows that after spraying with Paris green in the proportions indicated in the other article, 27.3 per cent. of the poisoned lot had been infested by the Curculios, and 51.3 per cent. of those not sprayed. With London purple his experiments show that 39 per cent. of the sprayed apples contained Curculios and 48 per cent of those unsprayed. His conclusion is: "If we must judge from results thus far reached, these various applications are of too slight effect upon the Apple and Plum Curculios to make them worthy of use against these insects, Paris green diminishing Curculio blemishes less than one-half, London purple about one-fifth, and lime not far from one-fourth."

We undertook some experiments through Mr. Alwood during the season of 1887. They were not begun until after the Curculios had begun to work. The following extracts from his notes will indicate the results:

Paris Green Spray.—Soon after the beetles appeared I became fully convinced that they ate a considerable amount of food and decided to try poisoning them. Three trees of green Gage variety were treated May 13th and 17th with Paris green at a rate of 1 pound to 50 gallons of water in very fine spray.

Some blue damsons were being used for other experiments, but I regretted, after seeing the results on the gages, that I did not treat some of the damsons with poison. Frequent observations showed that the fruit on the treated trees was not being stung so badly as the others. Much of the time a beetle could scarcely be found on them. The first spraying did not seem to injure the foliage, but shortly after second treatment it showed decided injury. I think this is accounted for by the cumulative effects of the poison. Both times the treatment was thorough, and coming so close together, was almost like a double-strength application. The foliage was badly burned and fully 50 per cent. fell off. The trees were set very full of fruit and much of this withered and fell. However, fully one-half of a crop was matured. There was one other tree in the orchard of this variety, and it matured more fruit than the other varieties, but not one-half as much as those which had been so thoroughly treated with poison. This tree was set in spring, as full as they were. It seems possible from this note that the gages are not so much injured by Curculio as other varieties. However, this is not at all certain. I am confident the curculios eat enough to make it possible to poison some of them, but the benefit to be derived from such is as yet unsettled.

Treatment with Paris Green under Glass.—May 23, placed twenty beetles on a branch of plum tree under bell glass, and sprayed thoroughly with Paris green, 1 pound to 50 gallons water. Two hours later several had fallen off and lay on their backs at bottom of glass. Eighteen hours, fourteen out of twenty are dead and all disabled. Thirty hours, three yet alive.

May 25, put two lots of Curculios under glass as before, one treated, the other not. After twelve hours seven dead of lot treated, five alive. Other lot all right, all eating and ovipositing. Twenty-four hours, all dead in lot treated, have scarcely eaten at all. Others alive and have cut and scarred the fruit badly.

On May 25 I noticed a number of beetles feeding on tender water sprouts growing around base of trunk of trees. They would gnaw along the side of a sprout for the distance of one-half to 1 inch. Many sprouts bent over from being thus weakened. This was noticed until Curculios disappeared. The young fruit had become so tough they seemed to prefer the twigs. Soon after the beetles appeared on the plum orchard they were also found in cherry orchard in great numbers, ovipositing rapidly. On May 17 two rows, seventeen trees each, were treated, the first with Paris green, 1 pound to 50 gallons water, and the second with standard kerosene emulsion diluted fifteen times. The row treated with Paris green seemed to be much freer from injury than those untreated. I intended to count the product of whole trees, thus getting at some facts in the case, but at picking time I found it impossible to determine accurately all infested ones without opening them. This I undertook to do with three trees only, one from each treatment and one check tree, but the labor necessary to do this was so great that I could not accomplish it before the fruit would spoil, and was compelled to give it up after counting several thousand cherries. So far as counted the tree treated with Paris green showed not quite 16 per cent. injured—an untreated tree 18 per cent.

In December, 1887, we received from Professor Cook the following statement, which is printed in the Department reports of the Michigan Agricultural College:

Paris green in the proportion of 1 tablespoonful to 6 gallons of water was very thoroughly sprayed upon four plum trees May 18. The petals had all fallen, but the dried calyxes still clung to the fruit. On August 20 the trees were visited, when it was found that the two treated trees of the Wild Goose variety had dropped all their fruit, as had the untreated trees of the same kind. Another treated tree of a yellow variety was loaded with plums, of which only 15 per cent. were stung, and those not badly. The fourth tree treated was a purple variety, and had not less than 75 per cent. of its fruit badly stung.

This experiment was worthless, as there is no record of check trees of the same variety, although the experiment upon the yellow variety looks well.

In Bulletin No. 4 (second series), Ohio Agricultural Experiment Station, Columbus, July, 1888, Mr. C. M. Weed records certain experiments upon Cherry which seem to have been made with sufficient care and from which results of decided value were obtained. His summary shows that on eight sprayed trees 280 infested cherries were found out of 8,000 counted, while on seven check trees (unsprayed) 1,086 infested cherries were found out of 7,500 counted, giving a percentage of benefit resulting from the spraying of 75.8. In other words, 75.8 per cent. of the fruit on the sprayed trees which was liable to Curculio damage was saved by the treatment with the poison. The poison used was London purple, one-half pound to 50 gallons of water, and was applied with a Nixon barrel machine and Climax nozzle. The trees were thoroughly wet at each application, and no injury to the foliage was done except in the case of two trees on which the liquid was forced in a solid stream. We reproduce Mr. Weed's summary and conclusions:

(1) These experiments were undertaken to learn what effect the application of London purple and lime to cherries, soon after the fruit forms, would have in preventing the injuries of the Plum Curculio, or in other words, in lessening the number of wormy cherries.

(2) For the carrying on of the experiment a half-acre orchard of bearing trees was set aside, and a part of it treated while the rest was left as a check.

(3) London purple was applied in a water spray, mixed in the proportion of one-half pound to 50 gallons water.

(4) Lime was applied in a water spray, mixed in the proportion of 4 quarts to 50 gallons, until the leaves were whitened.

(5) The cherries were critically examined when nearly ripe, and the exact number of specimens injured by the Curculio recorded. In this way 22,500 cherries were individually cut open and recorded.

(6) From eight trees sprayed thrice with London purple 8,000 cherries were examined, of which 280, or 3.5 per cent., were wormy, while from seven companion trees not treated 7,500 were examined, of which 1,086, or 14.5 per cent., were wormy. This represents a saving of $\frac{1}{14}$, or 75.8 per cent. of the fruit liable to injury.

(7) From two trees sprayed four times with London purple 2,000 cherries were examined, of which 69, or 3.45 per cent., were wormy.

(8) Two quarts of cherries from each of these lots were chemically examined at the time of ripening by Prof. H. A. Weber and showed no trace of arsenic in any form.

(9) Five trees sprayed four times with lime yielded 465 wormy cherries out of 5,000 examined, while five check trees yielded 778 wormy cherries from 5,000 examined. The percentage of the former was 9.3 while that of the latter was 15.6, which gives a percentage of benefit from the treatment of 40.3.

These experiments seem to me to show, so far the results of a single season's work with a single variety of cherry can be relied upon:

(1) That three-fourths of the cherries liable to injury by the Plum Curculio can be saved by two or three applications of London purple in a water spray (in the proportion 1 ounce to 5 gallons water) made soon after the blossoms fall.

(2) That if an interval of a month occurs between the last application and the ripening of the fruit, no danger to health need be apprehended from its use. As a precautionary measure, however, I would advise in all cases, and especially when there are few rains during this interval, that the fruit be thoroughly washed before it is used.

(3) That lime is not so certain in its preventive effect as London purple, saving in these experiments only 40 per cent. of the fruit liable to injury.

Some careful experiments were made for us upon plums by Prof. Herbert Osborn, our Iowa agent, during the past season. He has transmitted a report of the results, from which we quote:

The trees obtained for the purpose, and which were the most available in location and surroundings of any in the vicinity, were located in a small orchard of cherries, plums, etc., on the college grounds. They were distributed in three rows, but for the purpose of the experiment were numbered consecutively for each variety, as follows: DeSoto, five trees; Wolf, three trees; Maquoketa, three trees; Speer, four trees, and Rollingstone, six trees: in all, twenty-one trees, of which eleven were sprayed and ten left as checks. They were so situated that they had apparently about equal exposure to attack, though some, near the ends of rows, might have been subject to the first visits of the insects, and central ones possibly less exposed.

The trees were moderately small or medium in size, all young, and have been in bearing but a very few years. The De Soto were all small, 7 or 9 feet in height, nearly equal in size, 1, 2, and 3 almost of same size, 4 slightly smaller, and 5 smallest. All were set very full, and all produced, for their size, very heavy crops of fruit. The Wolf trees were larger, 1 and 2 quite good-sized trees, 3 smaller; all set very full, and more plums ripened than the trees could well support. The Maquoketa trees were all large, of nearly equal size, 3 smallest; all set very light and maturing but very few plums. The Speer trees were about equal in size, but set scarcely any plums, and after the first gathering of some half dozen plums none were taken under these trees, and it has seemed best to omit them entirely from the record. The Rollingstone trees were of medium size, about 10 to 12 feet high, with heavy tops, and blossomed very full, but set only a very few plums, nearly all of which fell before maturity.

The spraying was done with London purple, after the formula recommended in your instructions, namely, one-half pound purple to 100 gallons of water, with the addition of a small amount of soapsuds. The Cyclone nozzle was used, and each tree was sprayed so as to cover every part as thoroughly as possible, the spraying being continued till the leaves began to drip. The first spraying was on June 1, when the plums were of the size of small peas, most of them still retaining the withered calyx, and before any signs of injury from Curculios had been noticed. No heavy rains followed this spraying for a number of days; as there was a prospect of rain about eight days from first spraying, the second spraying was deferred

till the 11th, when the trees were given a second application, the proportions of poison and the method of spraying being the same as for the first.

The first indications of Curculios were noted June 4, when a very few plums were een with the characteristic punctures of the insect, one only bearing the crescent mark. On the 5th several plums were found gouged, but no Curculios as yet to be found. On the 6th I obtained one Curculio (*Conotrachelus nenuphar*) and one Gouger (*Anthonomus scutellaris*, Lec.) by jarring a tree not sprayed. The Curculio was inclosed in a jar with a twig of plums from a sprayed tree and the following day had punctured and marked one of the plums, but no eggs were to be found. On the 8th the puncturing had been continued and one egg was found. The Curculio was still active, and during the afternoon was transferred to a jar with a twig from a tree not sprayed. On the 9th it had continued puncturing plums and was still active and continued so for some days, making a number of crescent marks and punctures, but no more eggs were found. On the 14th it was given another sprayed twig and kept upon it for two or three days, but it lived afterward till the 21st. Another Curculio was captured (June 12) on a sprayed tree eating the surface of a plum, and was confined upon unsprayed plums. It remained active till the 23d of June. A Gouger collected June 12 from tree not sprayed was confined on sprayed plums. After it had made numerous punctures in these plums it was kept on plums not sprayed and lived till June 26. Another Gouger, collected June 14 on trees not sprayed, was kept for a time on sprayed plums, afterward on plums not poisoned, and lived many days longer than the others, but was dead on my return from a short absence in the early part of July.

While these observations are not very positive they show, if anything, that the insects are able to continue their work for some days after having fed upon poisoned fruit. It is, of course, difficult to tell at what time they have secured a sufficient amount of poison to prove fatal. The Gougers will evidently procure less of the surface of the plum, where the poison rests, than the Curculio, especially when the latter is gouging out the crescent marks.

But few examples were found to experiment with in this direction, as Curculios were at all times scarce, and to have shaken the trees to obtain specimens would manifestly have vitiated the results of comparison to determine the efficacy of the spraying. Punctures upon the plums were very few up till the 15th to 20th, after which they were for a time more noticeable.

As soon as plums began to fall after the Curculios had commenced their work I gathered them every few days, opened and examined each plum, recorded the number fallen under each tree, the number punctured, and the number containing larvæ or positive evidence of the growth of a larva. For the specimens gathered in early August, however, it was impossible in many of the plums to distinguish mere punctures of Curculios from other injuries, since a large proportion of these were attacked by a rot which obliterated such evidence, though it did not prevent detection of larvæ or their work. The record for fruit simply punctured, but not containing larvæ, is therefore given for only the fallen fruit previous to August 1, and for the ripened fruit collected in early September, and is stated simply in percentages. All possible care was taken in collecting and examing the plums, all being gathered, opened, and examined by myself, and the record I believe to be as nearly free from source of error as possible in a field experiment. Of the ripened fruit on the DeSoto and Wolf trees, all the fruit on certain branches was examined, representing for the DeSoto about half of all on the tree at the time, and for the Wolf about one-third of all.

I have given, in the following tables, the record for each tree, giving number of plums from each tree, number of larvæ, per cent. infested with larvæ, and also the per cent. of plums from each tree examined that were punctured or gouged by Curculio or Gouger.

DeSoto plum, five trees, 2,638 plums examined.

Trees numbered 1, 2, 3, 4, and 5. 1, 3, and 5 sprayed; 2 and 4 left as checks.

Tree No.	Plums examined.	No.	Contained larvæ.	Per cent. infested.	Per cent. stung.
1.........	Before ripe...	320	22	6.87	26.11
2.........	Ripe, or nearly so.......................................	164	11	6.71	43.24
	Whole number..............................	484	33	6.86	33.15
2.........	Before ripe.......	311	36	11.56	37.30
	Ripe, or nearly so	150	10	6.66	53.95
	Whole number..............................	461	46	9.98	44.28

Tree No.	Plums examined.	No.	Contained larvæ.	Per cent. infested.	Per cent. stung.
3	Before ripe	291	15	5.15	18.91
	Ripe, or nearly so	119	17	14.28	53.05
	Whole number	410	32	7.80	30.74
4	Before ripe	508	28	5.51	26.57
	Ripe, or nearly so	279	25	8.96	77.44
	Whole number	787	53	6.73	46.50
5	Before ripe	298	9	3.02	26.50
	Ripe, or nearly so	277	9	3.25	68.07
	Whole number	1,575	18	3.13	47.43
1, 3, and 5	Before ripe	909	46	5.05	23.98
	Ripe, or nearly so	581	37	6.36	5.44
	Whole number	1,490	83	5.57	38.55
2 and 4	Before ripe	819	64	7.81	30.28
	Ripe, or nearly so	429	35	8.18	68.71
	Whole number	1,248	99	7.93	45.71

There is here a perceptible result in favor of the sprayed trees, showing in both the amount of damage by puncturing, and in the number infested with larvæ; in the latter case, the sprayed trees showing 30 per cent. less of larvæ than the checks.

Wolf plum, three trees, 4,062 plums examined.

Trees numbered 1, 2, and 3. 1 and 3 sprayed, 2 left as check.

Tree No.	Plums examined.	No.	Contained larvæ.	Per cent. infested.	Per cent. stung.
1	Before ripe	1,310	68	5.19	34.28
	Ripe, or nearly so	301	11	3.65	17.96
	Whole number	1,611	79	4.90	30.82
2	Before ripe	1,177	105	8.97	36.11
	Ripe, or nearly so	228	10	4.38	22.61
	Whole number	1,405	115	8.18	33.83
3	Before ripe	686	27	3.93	25.28
	Ripe, or nearly so	360	6	1.77	14.55
	Whole number	1,046	33	3.15	21.78
1 and 3	Before ripe	1,996	95	4.75	30.97
	Ripe, or nearly so	661	17	2.57	16.20
	Whole number	2,657	112	4.21	27.16

In this case the effect of spraying is much more perceptible in the less number of larvæ than in the reduction of punctures, for while nearly as many plums were stung on sprayed as unsprayed trees, only a little more than half as many were found to contain larvæ, the spraying preventing 48.55 per cent. of the damage that would have been expected on the trees sprayed if attacked in same proportion as the check.

Maquoketa plum, three trees, 164 plums examined.

Trees numbered 1, 2, and 3. No. 2 sprayed, 1 and 3 left as checks.

Tree No.	Plums examined.	No.	Contained larvæ.	Per cent. infested.	Per cent. stung.
1	Before ripe	54	15	27.77	76.31
2		41	20	48.97	90.32
3		69	33	47.97	93.75
1 and 3		123	48	39.02	86.04

The result here is favorable to the checks, which must of course be accidental. The number of plums examined was too few to make the results in any case of much value.

Rollingstone plum, six trees, 103 plums examined.

Trees numbered 1, 2, 3, 4, 5, and 6. Nos. 1, 3, and 5 sprayed; Nos. 2, 4, and 6 checks.

Tree No.	Plums examined.	No.	Contained larvæ.	Per cent. infested.	Per cent. stung.
1		4	1	25	50
2		5	3	60	80
3		9	6	67	83.33
4		9	6	67	100
5		37	20	54	88
6		39	23	59	60.87
1, 3, and 5		50	27	54	82.85
2, 4, and 6		53	32	60	67.74

These show a greater amount of puncturing but a less number of larvæ for the sprayed trees, and are thus in a slight degree favorable to the spraying as destructive to the Curculio, but the number of plums examined is too small to give the record much if any value, and both this and the preceding table are given rather as showing the extent to which larvæ develop in these varieties than as furnishing positive evidence either for or against the efficacy of spraying.

Combining the entire count of all varieties, and we have for the sprayed trees a final of 32.48 per cent. punctured or stung, and 5.71 per cent. containing larvæ, against a final of 41.86 per cent. stung and 10.39 per cent. containing larvæ for the check trees.

The proportion of plums injured in this orchard was evidently so small that there would be no profit in spraying, though it can not be said but that Curculios were killed on the poisoned trees that otherwise would have laid eggs upon both sprayed and check trees and thus have produced great damage. It is possible, also, that a stronger solution of London purple would have produced more decided results. The foliage was not injured in the least, and I think a solution one-half stronger might have been used, at least for the second spraying, without injury. It might also be worth while to spray three times, at intervals of six days.

HERBERT OSBORN.

Mr. Edwin Yenowine, of Edwardsville, Ind., reported to our agent, Mr. Webster, the result of spraying his plum trees with Paris green in the proportion of half a pound of the green to a barrel of water last season. He had the most perfect success, but gives few details. One Wild Goose tree standing in his yard on grass was treated and the fruit was perfect. Two others of the same variety standing in a chicken-yard were not sprayed and the fruit was "all stung." Two other trees resembling the Blue Gage, which stood in his yard and the fruit of which had always before been stung, were sprayed with the Paris green mixture and bore a heavy crop.

We learn from the *Prairie Farmer* of August 11, 1888, that Professor Forbes has been experimenting further in this direction during the past season on Peach, Plum, and Cherry, and that he has found it practicable to destroy the Curculios with 1 pound of London purple to 100 gallons of water. One to 50 injured the foliage and 1 to 200 did not kill the Curculio. The details of his experiments are not yet published so far as we are aware, but he doubtless has the best grounds upon which to base so broad a statement.

The testimony which we have so far given is all favorable in a greater or less degree to the use of the arsenical sprays against the Curculio. The remedy has had to make its way to popular favor against great odds, and so many persons have taken part in placing it before the public that it is useless to attempt to give any one individual particular credit. The successful use of arsenical mixtures against the Canker Worm and the Codling Moth has done away with

a great part of whatever fear of the poisonous nature of these substances existed, and the objectors to its use have been for the most part those who were more or less familiar with the habits of the insect and who decried the use of this remedy as inconsistent with what they knew of these habits. There have been, however, unsuccessful experiments, and these have doubtless had their effect in deterring other experimenters. For example, the *Country Gentleman* for December 2, 1886, contained the following paragraph:

Paris Green for Curculio.—The various reports which have been made from the experiments of the present year lead to the conclusion that arsenic in any form is of little value against the Curculio. The insect works inside the fruit, and the egg is laid beyond the reach of the poison, or at best the spraying affects only a part of them. A report made by G. W. Trowbridge to the Ohio Horticultural Society on this subject is a fair sample of many others. He stated that he had experimented for two years. The first year he tried Paris green, the next London purple; in one instance with two applications and in the other with three as soon as the blossoms were off. No effect was produced on the Curculio, but the poison was perfectly effectual in the Codling Moth. President Ohmer did not think arsenic would affect the Curculio. O. W. Aldrich had tried London purple, a heaped teaspoonful to 3 gallons of water, at a cost of a quarter of a cent a tree.

On the whole the remedy is one which is a desirable addition to our list, although it will never become so great a success as the application of these poisons for the Codling Moth, and for two reasons: (1) The egg is deposited and the beetle gnaws preferably upon the smooth cheek of the fruit, where the poison does not so readily adhere, and from which it is more easily washed off; (2) the larva, eating directly from the flap, does not come in contact with the poison as does the larva of the Codling Moth.

THE SUPPOSED IMMUNITY OF WILD PLUMS AND MR. WIER'S THEORY AS TO ITS CAUSE.

As already stated in the section on "preventives," Mr. D. B. Wier, formerly of Lacon, Ill., now of California, a well known fruit-grower and writer, has claimed in different publications, and particularly in Bulletin No. 14 of this Division, that the cultivated species of native plums, such as Americana, Chickasa, etc., and their varieties, Rollingstone, Miner, Newman, Wild Goose, and others, are Curculio proof, the assumption being that the larvæ are not able to develop in these fruits. He states that but one egg in each two or three thousand deposited ever comes to maturity; and further, that the beetle is strongly attracted to these varieties in preference to all other fruit. The conclusion he draws is that to cultivate these varieties in abundance would exterminate the Curculio.

In the introduction to Bulletin 14 and in occasional foot-notes in the same bulletin we have expressed our dissent both from Mr Wier's premises and from the statements upon which he bases his conclusions. Without giving exact details, however, he claims that his statements are based upon experiment, and we have not been able to repeat them, except in a general way and to a certain degree theoretically. Our own past experience has been that wild plums are quite generally affected by *Conotrachelus nenuphar* and that the insect readily develops in them. Plums generally, either cultivated or wild, are preferred by the insect to peaches and other rough-skinned fruit, and we may say that it is also true that a certain percentage (sometimes quite a large one) of the larvæ perish in all kinds of fruit.

In the absence of definite experiment and accurate account to sup-

port our views we have endeavored during the past season to have observations made by certain of our agents and by several persons whom we knew to be at the same time accurate observers and more or less extensive growers of plums. Unfortunately for our purpose, the reports from these individuals have not all been received, but from those which have arrived there is a perfect concensus of facts and conclusions which subvert Mr. Wier's theory. We quote from a few of these replies:

Mr. F. Lionberger, of New Florence, Mo., writes under date of July 17, as follows.

In answer to your inquiry of June 22 as to whether or not the larva of the Curculio is able to develop in the cultivated species of *Prunus americana* and *Chickasa*, I will have to report that upon a very careful examination I find that at least 50 per cent. of the eggs deposited in my Wild Goose plum have hatched and ruined the fruit. I have carefully examined the fruit and have based my calculations on the specimens in which I found the larvæ or where it had been feeding. Upon the wild plums I have examined, I found the average to be slightly less. I have also made examinations in other orchards and found the average about the same.

Mr. G. C. Brackett, secretary of Kansas State Board of Agriculture, writes under date of July 7, 1888:

* * * My own experience and observations will not sustain Mr. Wier's declarations in the least, as I have been a close observer of this class of fruit for years in Iowa where the woods abound with them; also in the thickets skirting the water courses of this State, and some seasons have witnessed the total destruction of a heavy crop of fruit by the insect in question. In cultivated plantations of the Wild Goose, Miner, and several other sorts of the Chickasa family, both on my own farm and others which I have had the privilege of visiting in this State, I have not discovered any material exemption in varieties, and all varieties have suffered as much as the Lombard Washington and that class. * * *

Prof. Herbert Osborn, of Ames, Iowa, whose report upon experiments with arsenical poisons we have printed in full in earlier pages, and whose careful tables indicating the varieties of plums experimented upon and subsequently examined may be found in the same connection, writes concerning the Wier theory as follows:

With regard to the development of the Curculio larvæ in wild plums or varieties recently derived from wild forms, the tables already given will furnish some light, since for those reported as containing larvæ the eggs had in all instances hatched, and in nearly all cases the larvæ were well on their way to full development, or, in some cases, fully grown or even escaped from the plum, their presence being indicated by the condition of the pulp. The infested plums were placed in breeding jars, but since they had all been cut open and could not be given exactly natural conditions, it could not be expected that they would mature as perfectly as under normal conditions. Moreover, some of them produced the common Curculio parasite, *Sigalphus curculionis*. Nevertheless, a number of adult Curculios were bred from each of the varieties, at least three of which are closely related to wild plums. On June 25 I visited the timber in the vicinity and examined the native plums, cutting open numerous examples of the fruit and finding in very many cases well-developed larvæ. It seems to me, therefore, that there can be no reason to doubt that both Curculio and Gouger will develop readily in all the varieties of wild plum, although, of course, many plums will be stung that will not mature the insect, doubtless much of the puncturing being simply for food and no egg being laid.

The most elaborate experiments which we have had made are those of our agent, Mr. F. M. Webster, of Lafayette, Ind., and these we print in full at the end of this article. They do not, unfortunately, have a very definite bearing on the question at issue, for nearly all the varieties with which he experimented are of native stock. So far as they indicate comparisons, however, they show no difference in favor of wild stock.

After this consideration of the facts it will be unnecessary for us to make further comments.

EXPERIMENTS IN REARING THE PLUM CURCULIO (Conotrachelus nenuphar) FROM PLUMS AND OTHER FRUITS.

By F. M. WEBSTER.

The fruits used in these experiments were obtained from various sources. A large consignment of plums and nectarines was sent me by Mr. E. Yenowine, of Edwardsville, Ind., but, though they had all fallen from the trees, comparatively few had been attacked by the Curculio, and hence the limited number of specimens used in experiments 16, 17, 18, 19, and 20.

A fine lot of 447 plums, of seven varieties, was sent me on June 30 by Mr. C. M. Hobbs, nurseryman, of Bridgeport, Ind. Owing to a blunder on the part of the express company, the package did not reach me until two weeks after. The fruit was by this time rotted and mouldy, but in the box in which it was consigned I found ten full-grown larvæ, from which I reared seven adults. The decomposed state of the fruit when received forbade my learning the average number of punctures per plum. But Mr. Hobbs stated that not over one-third of the plums on his trees were stung at all, and the average would be less than five punctures per each plum.

The fruit from Mr. Aper's orchard was all growing within an area of less than 50 yards square.

The University orchard is composed of young trees, and these fruited sparingly. I used nearly all of the punctured, fallen fruit, in these investigations. These experiments were made by burying ordinary 8-inch drain tile vertically in the earth, the top projecting about an inch above the surface. The tile was filled with soil to within an inch of the top, including the sod where it was used; and over the top of the tile ordinary wire fly screen was drawn, and held in place by iron band, fitting over the end of the tile, forming a sort of cap. Within and on the surface of the inclosed earth the infested fruit was placed. The specimens were counted, and a record kept of each tile. The final examination was made by washing all of the earth contained in these tiles, through screen sufficiently fine to retain either the adult, larvæ, or pupæ. Grass of sod in tile was allowed to grow up as on outside.

Experiment No. 1.—June 13. Ten Rollingstone plums, from University orchard, were placed on sod. Result of examination on August 23, four adults were found, all dead.

Experiment No. 2.—June 15. Twenty Robinson plums, from University orchard, placed on sod. Result of examination on August 23, two adults, both dead.

Experiment No. 3.—June 16. Ten Wild Goose plums, from orchard of S. H. Beckner, Battle Ground, Ind., placed on sod. Result of examination on August 28, one adult, dead.

Experiment No. 4.—June 16. Twenty wild plums, from same orchard as No. 3, placed on sod. Result of examination on August 28, one adult, dead.

Experiment No. 5.—June 19. Twenty-one wild plums, from orchard of Mr. Aper La Fayette, Ind., placed on sod. Result of examination on August 28, no Curculio found.

Experiment No. 6.—June 19. Twenty-one wild plums, from same orchard as No. 5, placed on hard, bare ground. Result of examination on August 28, one adult dead.

Experiment No. 7.—June 19. Thirty-nine Wild Goose plums, from same orchard as No. 6, placed on sod. Result of examination on August 28, one adult, dead.

Experiment No. 8.—June 19. Thirty-nine Wild Goose plums, from same orchard as No. 7, placed on hard, bare ground. Result of examination on August 29, no beetles.

Experiment No. 9.—June 20. Fourteen Siberian Crab apples, from same orchard as No. 8, placed on sod. Result of examination on August 29, no beetles.

Experiment No. 10.—June 20. Thirty-six seedling apples, from same orchard as No. 9, placed on sod. Result of examination on August 29, eight adults, all alive.

Experiment No. 11.—June 20. Thirty-six seedling apples, from same tree as No. 10, placed on hard, bare ground. Result of examination on August 29, fourteen adults, all but two living.

Experiment No. 12.—June 22. Thirty Robinson plums, from same tree as No. 2, placed on loose soil. Result of examination on August 23, eight adults were found, all dead.

Experiment No. 13.—June 22. Thirty Robinson plums, from same tree as No. 12, placed on bare, hard ground. Result of examination on August 23, eleven adults were found, all dead.

Experiment No. 14.—June 22. Twenty Robinson plums, from same tree as No. 13, placed on sod. Result of examination on August 29, twelve adults, all dead.

Experiment No. 15.—June 22. Thirty-five Golden Beauty plums, from University orchard, placed on sod. Result of examination on August 29, no beetles.

Experiment No. 16.—June 25. Seven Kansas sand plums, from E. Yenowine, Edwardsville, Ind., placed on sod. Result of examination on August 29, no Curculio.

Experiment No. 17.—June 25. Six Wild Goose plums, from same locality as No. 16, placed on sod. Result of examination on August 29, no Curculio.

Experiment No. 18.—June 25. Nine Chickasaw plums, from same locality as No. 17, placed on sod. Result of examination on August 30, one adult, living.

Experiment No. 19.—June 25. Five Blue Gage plums, from same locality as No. 18, placed on sod. Result of examination on August 30, two adults, dead.

Experiment No. 20.—June 25. Eleven nectarines on sod. Result of examination on August 30, no Curculio.

Experiment No. 21.—June 26. Six De Soto plums, from University orchard, on sod. Result of examination on August 30, no Curculio.

Experiment No. 22.—July 5. Twenty-eight wild plums, from Aper's, same trees as No. 4, placed on sod. Result of examination on August 30, no Curculio.

Experiment No. 23.—July 5. Thirty-two Wild Goose plums from Aper's, same tree as No. 6, placed on sod. Result of examination on August 30, two living adults.

Experiment No. 24.—July 5. Twenty-one Siberian Crab apples, from Aper's, same tree as No. 9, placed on sod. Result of examination on August 30, nothing.

Experiment No. 25.—July 5. Ten late cherries, from Aper's, placed on sod. Result of examination on August 30, nothing.

Experiment No. 26.—July 5. Thirty-two seedling apples, from Aper's, same tree as Nos. 10 and 11, placed on sod. Result of examination on August 30, nothing.

RECAPITULATION.

Whole number of plums used in experiments (not including those sent by Mr. Hobbs), three hundred and eighty-eight; number of Curculio reared, forty-six, or one to each eight-tenths of twenty-three plums.

Of the three principal varieties used, the wild plum gave one Curculio to every forty-five. The wild goose one to every thirty-one and one-half. The Robinson nearly one to every three. The cherries gave no adults in ten. The crab-apples none in thirty-five. The nectarines none in eleven. The seedling apples one to four and eight-elevenths.

Unfortunately, the idea of counting the punctures in the fruits before placing the latter in the tile did not occur to me until too late; but I am satisfied that the average would not be above two punctures per plum.

With a view of learning something of the fatality to the eggs and young larvæ, we examined a large number of plums, the results of such examinations being tabulated below. I have there assumed that each crescent-shaped mark on the fruit represented one egg, although it is doubtful if this is correct. It is, however, safe to say that there would not be more than one egg in each cavity. If there was a chamber connected with a puncture, this was considered proof of the egg having hatched.

Of the fruit examined and the results given below, lot 1 was from same tree as the fruit used in experiment No. 1. Lot 2 from same tree as fruit used in experiment No. 15. Lots 3 and 9 from same tree as experiments 2, 7, 8, 12, 13, and 14. Lot 4 was from same source as fruit used in experiments 4, 5, 6, and 22. Lot 8 was from same tree as fruit used in experiment No. 21.

Number of lot.	Date of examination.	Variety of fruit.	Picked or fallen.	No. of examples.	No. of punctures.	No. of channels.	No. of living larvæ.	Proportion of eggs hatching.	Proportion of larvæ alive when hatching.
1	July 3	Rollingstone	Picked	9	25	11	3	11–25	3–11
2	July 6	Golden Beauty	....do	10	13	5	2	5–13	2–5
3	July 6	Robinson	Fallen	15	33	12	6	12–33	6–12
4	July 6	Wild	Picked	14	16	3	2	3–16	2–3
5	July 6	Wild Goose	Fallen *	25	43	32	26	32–43	26–32
6	July 6	....do	Picked *	15	21	5	2	5–21	2–5
7	July 7	Speer	....do	4	9	6	0	6–9	0–6
8	July 7	De Soto	....do	5	14	3	2	3–14	2–3
9	July 7	Robinson	....do †	15	22	6	1	6–22	1–6
	Total			112	196	83	44	83–196	44–83

* From same tree. † From same tree as No. 3.

THE FLUTED SCALE.

(*Icerya purchasi*, Maskell.)

Order HOMOPTERA; family COCCIDÆ.

[Plates VIII, IX, X, and XI.]

Considerable interesting matter concerning this insect has accumulated since the publication of our extended article upon it in the annual report of this Department for 1886. We have published a number of shorter articles since, some of them fugitive in their nature, and it is our purpose in this report to bring our investigation of this species up to date. All facts which we give will be supplementary to the 1886 report unless otherwise stated, the report for 1887 containing, aside from a few words in the Introduction, only reports from Messrs. Coquillett and Koebele on the subject of remedies. In the meantime additional experimenting, particularly with gases, has been carried on, other food-plants have been found, new facts bearing upon geographical distribution and the original habitat of the species have come to light, a number of new natural enemies, principally parasites, have been discovered, and most interesting results have been reached by the study of the Australian natural enemies of the pest and by their introduction into California.

THE ORIGINAL HOME OF ICERYA PURCHASI, AND ITS VALIDITY AS A SPECIES.

The discussion of the original home of the pest can not well be separated from a discussion of its identity or non-identity with *Icerya sacchari*, the type of the genus, and which we may incidentally remark is synonymous with Westwood's *Dorthesia seychellarum*, as will be shown later. We shall therefore consider both questions under this section.

In our 1886 report the conclusions at which we arrived respecting these two points were that the species is a native of Australia, and that it is distinct from the sugar-cane species of Mauritius. Soon after the publication of this report, however, other facts came to our notice which led to some modification of opinion upon both points. In originally deciding upon the non-identity of *purchasi* and *sacchari* we relied almost entirely upon the fact that Maskell, in 1883, had specimens of both species before him for comparison. A letter which Mr. Maskell wrote to Mr. Klee in April, 1887, and which was published in the *Pacific Rural Press* for May 7, 1887, brought up anew the question of the accuracy of his determination, and it seemed to us from the information which we then possessed that the two species might after all be identical, and that in consequence the original home may have been Mauritius or the island of Bourbon (Reunion). On this hypothesis it seemed that the species might owe its comparatively wide distribution to importation with sugar, being conveyed particularly upon the draining canes placed in hogsheads packed for exportation. Our reasons for this partial conclusion we published at length in the *Pacific Rural Press* for June 11, 1887, and subsequently reprinted the article in Bulletin 15 of this Division, pages 27–33 (issued August 18, 1887), mentioning them also at the meeting of the British Association for the Advancement of Science held at Manchester in August, 1887.

During the summer of 1887 and the winter of 1887–'88, by corre-

spondence and personal investigations in Europe, we were able to throw new light upon both questions. These results we summed up in an article published in the *Pacific Rural Press* for May 12, 1888, from which we quote at some length:

My search for the original habitat of *Icerya purchasi* has led to much interesting correspondence with naturalists in different countries, and a number of side veins have been struck and followed up with important results. At the time of my communication to the *Pacific Rural Press* of June 11, 1887 (reprinted in Bulletin 15 of the Division of Entomology), I was rather inclined to the opinion that *purchasi* might be a synonym of *sacchari*, and that the original home of the species would turn out to be the islands of Bourbon and Mauritius. The correspondence there published with Messrs. Trimen of Cape Town, Crawford of Adelaide, Kirk of Wellington, and Baron von Mueller of Melbourne developed nothing to alter this impression, but rather confirmed it; and I was particularly anxious to get some exact information from the islands in the Indian Ocean. * * * I have arrived at a definite conclusion contrary to the surmise of last June with regard to the identity of these two insects, and this conclusion was formed first from a study of Signoret's types in Paris and subsequently by a bit of roundabout correspondence which is of sufficient interest to be treated at some length. I was very sorry to find, when in Paris last October, that my old friend, Dr. Signoret, was extremely sick and unable to give any attention to affairs, and, as he was at his country place, I had some difficulty in making an examination of his types; but, finally, through the courtesy of M. Fairmaire, I succeeded in making a study of them, and, although the specimens were for the most part pinned and dried and in poor condition for comparison, yet enough perfect material remained to make me quite positive that *sacchari* was distinct from *purchasi*. In the meantime, during my visit to Europe, another specimen of the old original lot sent by Dr. Icery, of Mauritius, to Signoret in Paris, in 1874, or thereabouts, and which was the one sent by Signoret to Maskell in New Zealand in 1878, was received from Mr. Maskell and immediately forwarded across the Atlantic by Mr. Howard, and later was brought back to Washington, where it now remains, probably the most traveled insect in any collection. This specimen also was in poor condition.

My second verification of the conclusion of non-identity was arrived at as follows: Mr. J. Horne, director of the Botanic Gardens at Port Louis, Mauritius, replying to my communication asking for particulars and specimens concerning the "Pou blanc" in Mauritius, informed me that the insect was there also known as the "Pou anglais," and was supposed to have been described by an English entomologist many years ago as *Dorthesia seychellarum*. Reference to all accessible works failed to give me a clew to any such species of *Dorthesia*, and application was made to Mr. J. W. Douglas, of England, who has monographed the genus, for information concerning the use of this name. Through his kindness I learned that the insect was briefly described by Westwood in the *Gardeners' Chronicle* for December 22, 1855. On consulting this article I found the insect figured both from a dorsal and ventral aspect, with also an enlarged representation of the antenna of the female. I saw at a glance that the insect was the same as that described by Signoret as *Icerya sacchari*, and that it was no *Dorthesia*. The "Pou blanc" is therefore *Icerya seychellarum* (Westwood). The specific name was given to this insect by Westwood from the fact that the insect was received upon the leaf of a palm from the Seychelles Islands.

The third verification was made in a roundabout way almost at home. Learning from Mauritius that Col. Nicholas Pike, United States consul at that island many years ago, had, while in Mauritius, paid some attention to this insect, I wrote to Colonel Pike, who at present resides in Brooklyn, N. Y., and was much gratified upon receiving a long and interesting communication from him. Among other facts he stated that some twenty years since he deposited with a lot of other natural history objects a few specimens of the "Pou blanc" with Prof. Louis Agassiz at Cambridge. I then wrote to Dr. Hagen, who was at once able to place his hand upon the specimens mentioned by Colonel Pike, and who most courteously forwarded three of them, all in admirable preservation, as they had been saved in alcohol. These correspond with Signoret's description, and with Signoret's and Maskell's specimens, and with Westwood's figures and description.

We are still, it will be observed, without positive and absolute knowledge as to the original habitat of *Icerya purchasi* outside of Australia, so that I am rather confirmed in my first conclusion that it is an Australian species, though I shall not be surprised if, in the course of the next few months, specimens turn up from Mauritius. There is a possibility that both the insects occur in that island, but all things considered, it is much more likely that *purchasi* was introduced from Australia to

the Cape of Good Hope, to New Zealand, and to California. The reasons which lead to these conclusions are as follows;

First. We do not know that *purchasi* occurs in Mauritius, Reunion, or any of the neighboring islands, while we do know that it occurs in several parts of Australia.

Second. The insect made its first appearance in South Africa, New Zealand, and California upon plants that are peculiarly and distinctively Australian.

Third. Although it may seem paradoxical, the very fact that the species does not appear to be very abundant or injurious in South Australia is rather an argument for than against its being an indigene there. Any one who has studied the history of insect outbreaks will appreciate this point. * * *

The figures and specimens of *Icerya sacchari* (*seychellarum*) which we have been able to examine and critically compare with *I. purchasi* are, then, as follows:

1. Signoret's figures in Ann. Soc. Ent. France, 1875, series 5, Vol. V, Pl. 8, Figs. 2, 2*a*, 2*b* (adult and enlarged antenna of adult and young).
2. Signoret's type specimens, examined by us in Paris, and of which we brought to Washington four females, with eggs and young.
3. Another of Signoret's type specimens, received by him from Dr. Icery in 1874 (?) and sent by Signoret to Maskell in 1878. This was sent us by Maskell in 1887.
4. Westwood's figure of *Dorthesia seychellarum*, in *Gardeners' Chronicle*, December 22, 1855, p. 836 (shows adult from above and below, enlarged, and natural size on leaf; also antenna of same still more enlarged).
5. Three adult females, from a number collected on sugar-cane by Col. Nicholas Pike in Mauritius, and deposited by him some twenty years ago with Professor Agassiz, at Cambridge; sent to us by Dr. H. A. Hagen, at Colonel Pike's suggestion.
6. A large number of females (twenty or more), mainly adults, sent us by Mr. D. Morris, of the Royal Kew Gardens, to whom they were sent from Rodrigues during the winter of 1887–'88.

It will thus appear that we had abundant opportunity to decide the question satisfactorily, and there can no longer be any doubt that *Icerya purchasi*, Maskell, is a perfectly valid species. The points of difference it will be unnecessary to detail, as this conclusion coincides with that stated in our 1886 report. Some words, however, may be devoted to the insects mentioned under No. 6. We had noticed on several occasions during the last year or two newspaper accounts of the damage done to various trees in Mauritius, and particularly to the forests, by what was called "the White Scale insect." We suspected that this might be *I. purchasi*, and entered into correspondence with gentlemen in Mauritius and with the authorities of the Royal Kew Gardens. Mr. D. Morris, of the Kew Gardens, finally succeeded in obtaining specimens and a report from which he briefed the facts for us that the damage was done at Rodrigues, a small island some 330 miles east-northeast of Mauritius, and that many trees were attacked. "The leaves, branches, and trunks are *white* with insects. They are chiefly found on the leaves along the midrib, but also largely on the young branches and on the trunks of young trees. Their size varies much; some are no larger than a poppy seed, and others are as large as a French kidney bean split in two." Mr. Morris also quotes for us, from the Report on the Forest and Crown Lands of Rodrigues, for the year 1886, the following, which evidently refers to the same insect: "Many trees which were already in a bad condition, owing to the prevalence of the Cochenille or Pou Blanc have died since. It was expected that some good

would come of the terrible effects of the cyclone of the 16th of April, 1886, * * * but the insects are now as numerous as ever."

The fine specimens (in alcohol) sent us by Mr. Morris show that the Rodrigues Pou Blanc is undoubtedly *I. sacchari*, and this determination is very interesting as indicating, in connection with the other facts, that the species is as polyphagous and destructive as *I. purchasi*.

The fact that this destructive species turns out to be *sacchari* and not *purchasi* adds one more slight proof to our conclusion that the original home of the latter is Australia, for the evidence is still negative as to the existence of *purchasi* in any of the islands of the Indian Ocean, whereas we had inferred from the newspaper accounts that the Rodrigues insect might prove to be *purchasi*. The experience of Mr. Koebele in Australia in his studies of the parasites of the Fluted Scale is also confirmatory, as he finds the insect widely spread over the country, but in almost all cases comparatively harmless owing to the numerous natural enemies which it has there.

From all of the facts gathered up to the present time we are therefore still inclined to the belief that the Fluted Scale belongs to the Australian fauna.

ADDITIONAL FACTS ON GEOGRAPHICAL DISTRIBUTION.

FIRST APPEARANCE IN CAPE COLONY.—In our 1886 article we led to the inference that the Fluted Scale made its first appearance at the Cape in 1873, from our quotation from the report of the Government commission published in 1877. We have since found the following in the *Gardeners' Chronicle* for March 21, 1874, which would seem to place the date a trifle earlier.

"Prof. Thiselton Dyer exhibited a specimen of an Acacia with a curious white balaniform exudation of insect origin. In explanation of it, he read the following extract from a letter from Mr. James McGibbon to Dr. Hooker, dated January 6, 1874:

> I have taken leave to inclose in the box, along with the seeds, a small box of insects, which I will ask you to be good enough to give me some information anent. This pest has only made an appearance within the last two years, and appeared first on a specimen of *Acacia melanoxylon*. It spreads with wonderful rapidity. Species of Acacia of Australian types are its preference; indeed, the insect is not found on any native plant. *Coccolobas platycladon* and *Pittosporum tobira* are covered with it. How shall I get rid of it? Perhaps some of your learned in these matters would assist me. It is quite a new infliction to the Cape.

"Professor Westwood stated that the insect upon the Acacia was quite new to him, and was closely allied to the *Cionops cataphractus*, a rather rare British insect, allied to the Coccidæ; the specimens were females, which had emitted a mass of waxy matter striated in ridges; the waxen mass was in many places covered with minute larvæ, differing in form from the ordinary larvæ of the Coccidæ."

IN CALIFORNIA.—In considering the infested districts of California we have included Anaheim, on the authority of the late Matthew Cooke. Mr. Cooke's words regarding this locality were as follows: "Anaheim, No. 8 on map, 27 miles south by east of Los Angeles. Local." We have recently learned from Mr. F. G. Ryan, of Anaheim (December 26, 1888), that at the present time this statement is unwarranted. He writes us in these words:

> I am now much interested in keeping that pest (Icerya) out of this district. * * * Icerya does not now exist in Anaheim or the surrounding country to my knowledge. I have had two cases reported, but one was not authentic, and the other occurred within six months and received some vigorous treatment at my hands.

IN AUSTRALIA.—We anticipate some exact facts as to the distribution of the pest in Australia as one of the results of sending Mr.

Koebele to that part of the world, but they have not yet come to hand and will be separately published.

IN MEXICO.—At the time of writing our last letter we were not aware of the existence of Icerya in Mexico. In January, 1888, however, we learned from Mr. Koebele that he had received a number of specimens which had been sent to Mr. Klee, by a German gentleman named Wolleb, from Hermosillo. Mr. Koebele wrote for further specimens and received about thirty from Mr. Wolleb, with the information that some three years ago they were very abundant on the trees in the public square at Hermosillo. The year following they entirely disappeared. In 1887 they re-appeared, and at the time of writing they were numerous again.

IN NEW ZEALAND.—We learn both by correspondence with Mr. R. Allen Wight, of Paeroa, Thames, Auckland, New Zealand, and from his articles in the *New Zealand Farmer*, over the the pseudonym of "Komata," that of late the Icerya has been decreasing in these islands. At Newmarket the insect has entirely disappeared; at Auckland it is stated to have been on the decrease for eighteen months prior to October, 1888. A correspondent at Hawke's Bay informed him that while the scale used to be very bad in that district upon acacias, roses, apples, English gooseberries, furze, lemon, and orange trees, the decrease is at present most marked. From Napier and Nelson practically the same state of affairs is reported. In the great orange-growing district of New Zealand, Whangerei, we are informed by Mr. Wight that the fruit-growers are a most energetic race; that they have established a vigilance committee; and that three separate times the Icerya has made its appearance only to be thoroughly stamped out. Upon one occasion, at least, the tree upon which the insect was found was cut down and destroyed, root and branch, by fire.

Altogether the outlook from this part of the globe is not discouraging, although Mr. Wight justly bemoans the indifference of the local government. He has been unable, through correspondence, to ascertain the cause of the decrease, but feels sure it must be because of the work of certain as yet undiscovered parasites.

ADDITIONAL FOOD PLANTS.

IN CALIFORNIA.—As supplementary to the lists of food plants given in our 1886 report, we may indicate the following, on all of which have been found adult females of the Fluted Scale with egg-masses, indicating that they had actually sustained themselves and flourished at the expense of the plant. Moreover, none of them were growing immediately under infested trees. All are presented on the authority of Mr. Coquillett:

Pittosporum tobira, many scales.
Myosporum sp., very many.
Anona cheirimoya, many.
Rosmarinus officinalis, few.
Prosopis sp., very many.
Tamarix gallica, few.
Plumbago capensis, few.
Tecoma jasminoides, few.
Cassia grandiflora, few.
Spiræa sp., many.
Gladiolus sp., few.
Populus dilatata, few.
Humulus, many.
Rubus (Raspberry), few.
Carya (Pecan), very many.
Salvia fulgens, few.
Baccharis viminalis, very many.
Nepeta sp., many.
Solidago californica, many.
Chrysopsis villosus, few.
Sonchus oleraceus, few.
Plantago sp., few.
Amaranthus retroflexus, many.
Ambrosia psilostachya, many.
Bidens pilosa, few.
Xanthium sp., few.
Solanum douglasii, many.
Polygonum persicaria, many.
Quercus douglasii, few.
Ficus macrophylla, very many.

NATURAL ENEMIES.

IN CALIFORNIA.—*Predaceous Insects.*—The principal additional notes on the California predaceous insect enemies of the Fluted Scale which we have to present are specific determinations of the three species of true bugs mentioned upon page 487 of our 1886 report by generic names only. Mr. Uhler has kindly given these insects further study, and writes us that the *Piezostethus* sp. is Reuter's *Piezostethus californicus* (Plate X, fig. 4), which ranges from Michigan to the lower part of California. The *Lyctocoris* is *Lyctocoris fitchii* (Plate X, fig. 5), also of Reuter, a synonym of the old *L. campestris* of Fabricius, a species which occurs in the United States from New York to Texas, and is also found in Western Asia and New Zealand. The third species, referred to in our former report as *Beosus* sp., is now determined by Mr. Uhler as *Eremocoris tropicus* Distant (Plate X, fig. 6), previously found only in Central America.

In 1887 Mr. Koebele sent us specimens of a *Chrysopa*, of which he had observed the larvæ preying industriously upon the adult females of Icerya and their egg-sacks. We are unable to determine this Golden-eyed Lace-wing fly, and upon consulting Dr. Hagen, of Cambridge, the authority upon the order to which it belongs, he informs us that he is not prepared either to determine or to describe it, as since the disheartening loss of his collection of Hemerobiidæ many years ago he has done no work upon this particular genus. This insect, from Mr. Koebele's account, seems to be an important enemy of the Fluted Scale. It is, however, unfortunately very subject to the attacks of parasites. Mr. Koebele has reared from its cocoons two species of Chalcid parasites, one a species of Pteromalus, and the other a species of Perilampus. He has also reared from the cocoons an Ichneumonid of the genus Hemiteles, which will probably prove to be a secondary parasite, preying upon the Perilampus. Mr. Coquillett has also reared the Pteromalus and the Perilampus, and, in addition, a Tetrastichus, which is undoubtedly a secondary parasite. Moreover, he has also found that *Isodromus iceryæ*, described in the 1886 report as a parasite of the Fluted Scale, is a parasite of this Chrysopa, and this observation will be further considered under the head of the parasites of the Icerya.

We briefly referred on page 487 to the occurrence of a mite at Los Angeles which destroys the scales. We have since received specimens, and have given it some study. We have found two species among the material sent us. One is a Gamasus, near *exilis*, Berlese, and the other is a species of Scirus, a genus the species of which resemble Gamasus in habits.

The common Lady-bird of the Cactus (*Chilocorus cacti*, Linn.), a common enemy of the larger scale insects in California, has been on several occasions observed to feed on the Fluted Scale in that State, and is unquestionably an important enemy of the scale. It is figured in all stages at Plate XI, fig. 1.

True Parasites.—In our 1886 report we recorded but one parasite of the Fluted Scale, viz, *Isodromus iceryæ*, Howard. This was reared from adult females of Icerya received November 10, 1886, from Los Angeles. Observations have since been made, however, which show that this parasite also infests the cocoons of the Chrysopa previously mentioned, and render doubtful even the seemingly positive observations upon which we recorded it as an Icerya parasite. Mr. Coquillett writes concerning it as follows: "I have never bred this species

from the Icerya, but have obtained four specimens from cocoons of a lace-winged fly (Chrysopa); two of these issued August 5, and two October 18, 1888. The two latter issued from a single cocoon spun by a Chrysopa larva September 23. They made their exit through an irregular hole in one end of the cocoon. After they had issued I examined the interior of the cocoon and found only the shriveled remains of the Chrysopa larva and the cast-off skins of the parasites. There were no traces of parasites of the Chrysopa, and I believe that it attacks the Icerya only when there is a scarcity of its usual prey." Mr. Coquillett is probably correct in this conclusion, as we have since found that another species of this same genus Isodromus attacks the cocoons of a Chrysopa which occurs on the grounds of the Department of Agriculture at Washington.

In an article entitled "Some Recent Entomological Matters of International Concern," published in the November (1888) number of Insect Life (Vol. I, No. 5), we have given a list of the parasites found to attack Icerya in California up to that date. They were, aside from the Isodromus just mentioned, *Coccophagus* n. sp., *Entedon* n. sp., *Alaptus iceryæ* n. sp., *Thoron* n. sp., and *Goniozus* n. sp. Since then we have found it necessary to add to the list a new species of the genus Encyrtus, and a closer study of the facts has led us to omit the Goniozus, as it seems probable that it is not a parasite of Icerya, but of the predaceous Lepidopteron (*Blastobasis iceryæella*) described in our last report. The other species may be known as *Entedon coquillettii* Riley (Plate X, fig. 1), *Alaptus iceryæ* Riley (Plate XII, fig. 3), *Coccophagus californicus* Howard (Plate XI, fig. 3), *Thoron opacus* Howard (Plate X, fig. 3), and *Encyrtus dubius* Howard (Plate XI, fig. 1), and will be described in the columns of INSECT LIFE.

IN SOUTH AFRICA.—*Predaceous Insects.*—The most important of the insect enemies of the Fluted Scale in South Africa appears to be the little Lady-bird beetle mentioned in our 1886 report as *Rodolia iceryæ*. It was originally sent to Miss Ormerod, in England, by Mr. S. D. Bairstow, of Port Elizabeth, Cape Colony, and Miss Ormerod has kindly sent us a specimen, from which our figure was drawn. In a pamphlet entitled "Notes on the Australian Bug (*Icerya purchasi*) in South Africa," published by Miss Ormerod in 1887, the author quotes quite a glowing account of the work of this insect from a letter from Mr. Bairstow. She also in this paper prints the original description of the species, of which Mr. O. E. Janson is the author. Both as larva and adult this lady-bird is an active feeder upon the eggs, young, and full-grown females of Icerya. Mr. Trimen, of the South African Museum, has also received accounts of the beneficial work of this beetle from a correspondent, Sir Thomas Scanlan, of Cradock.

Principally from the account of this beetle given by Miss Ormerod in her pamphlet, the New Zealand people made a successful effort last year and introduced living specimens into New Zealand. There is now at Nelson, as we are informed by Mr. Wight, a colony of 150 or more, and all are thriving exceedingly well. The beetle itself is about 5^{mm} long and of a dull black color, with a single red spot at the base of the wing-covers. The underside of the body and the legs are red-brown, while the whole upper surface appears somewhat dusty or powdered, from the dense short pubescence with which it is covered. Figure 8, Plate X, will enable its recognition.

Another beetle which appears to be almost an equally important

enemy of the Icerya is mentioned by Mr. Trimen in an article in the *Cape Argus* (Cape Town, South Africa), of December 28, 1887.

It was brought to his notice by Mr. George Rex, of Knysna. This is one of the Soldier-beetles, and was determined by Mr. Peringuey as *Telephorus circumdatus*. It is described as a narrow, elongate insect with thread-like antennæ and rather long, slender legs; the head and front joint of the thorax are small in proportion to the rest of the body; it is of a soft consistency throughout, and the long, narrow wing-covers are very thin; the color above is dull gray, sometimes with a dark-gray stripe down the middle of each wing cover; the head is blackish and the under side of the body is dark gray. It measures from 6 to 9^{mm} in length. According to Mr. Rex, this beetle was first noticed at Knysna during 1885, and attacked the Icerya on some orange trees with such effect that they soon cleared them. During 1887 the beetles were much more numerous and nearly cleared the scales from some acacias which a month before were literally covered with the pest. The larva of the beetle was not noticed, and when the beetles themselves seemed to be engaged in the work of destruction, their method of work was to tear open the white scales and devour the eggs.

IN NEW ZEALAND.—*Predaceous Insects.*—Beyond the specimens of *Rodolia iceryæ* introduced into New Zealand we have no definite information concerning the insect enemies of the Fluted Scale in that colony. Mr. Wight has industriously corresponded with a number of gentlemen, who have informed him that the sac was being destroyed in their respective localities by certain insects, but so far we can learn of no authoritative specimens having been received and determined up to the present time. Concerning the introduction of the Rodolia, we quote a detailed account from the *Otago Witness* of February 3, 1888, since reprinted in INSECT LIFE for February, 1889:

> An interesting experiment is being conducted at Nelson in the way of acclimatization. It appears that some of the finest trees in and about Nelson have been destroyed by the Wabble Blight, or Australian Bug. Mr. Tinline, while at Cape Town, read there a pamphlet by Miss Ormerod, the entomologist, entitled "Notes on the Australian Bug (*I. purchasi*) in South Africa," which stated that the grubs of a coccinellid, or lady-bird, have been observed by Mr. Bairstow to do much good by destroying the young Australian bugs just at hatching time within the sac of the female. Of these Mr Bairstow says:
>
> "The Coccinella is by far our best friend. It is proving a perfect godsend in destroying the perfect young *in nidus* of the female 'bug.' The larva buries itself in the gravid female and completely destroys her progeny, the dead carcass falling to the ground; and it eats the 'bug' not only when it (the Coccinella) is young, but when it has developed to beetle condition." Mr. Tinline accordingly wrote to a friend in Cape Town, asking him to procure some of the lady-birds, which he did, and one hundred and twenty of the little beetles were caught, put into a bottle with a good supply of the "bugs" to feed upon, and shipped on board of the *Tongariro*. On arrival in New Zealand (passage twenty to twenty-two days, steamer) it was found that by far the larger number of them were alive and healthy. A few were given to Mr. Maskell in Wellington, and the remainder brought on to Nelson. Mr. Maskell's advice was to select some small shrub infested with the blight, cover it carefully with muslin, and then turn the lady-birds into this cage. A young lemon tree, to which the bug is paying great attention, was selected in Mr. Sharp's garden for the purpose, and there the little colony of lady-birds is to all appearances thriving.

IN MEXICO.—*Predaceous Insects.*—Among the Hermosillo specimens of Icerya mentioned in a previous paragraph, Mr. Koebele found a number of puparia of a small fly which, when forwarded to Washington, proved to be those of a species of Phora. Although the flies of this genus are normally scavengers, and seldom if ever to be considered as true parasites, there seems to be little doubt that this

Mexican species is of assistance in reducing the numbers of the Fluted Scale. Mr. Koebele secured from Hermosillo a lot of about fifty female scales with egg-masses. Although some of the scales were still living and remained alive in his possession for some time, not a single young hatched from the whole lot. Empty puparia of the Phora were found in all of them, five within a single egg-mass. Specimens which he sent to us at Washington show that the egg-sac is perfectly empty, and that the body of the mother scale was partly devoured. Later, thirty more adult females of Icerya were received from Hermosillo. All except six were living, while the dead ones had eggs as well as young in their egg-sacs. Twelve puparia of the Phora were found among them. The adult flies were bred and fed for some time upon slices of apple, but Mr. Koebele was unable to induce them to oviposit, although he kept the adults alive for nearly a month.

Mr. Koebele also received in his last lot of Hermosillo specimens an adult Lady-bird, which, from his description, seems to have been a small specimen of *Chilocorus cacti*. Upon opening the box Mr. Koebele saw it seize a newly hatched scale and devour it; then it ate a large scale, and finished up with a Phora puparium.

IN AUSTRALIA.—*Predaceous Insects.*—We have received from Australia two insects which prey upon Icerya, both of which are voracious and do good work, and both of which have been imported to this country. The first of these is a Chrysopa, very similar to the one found in California. It will be left unnamed and undescribed for the same reason mentioned under the head of the California Natural Enemies. The second is a Lady-bird, which is shown at fig. 7, Plate X. It is about 2.5 or 3^{mm} in length, slightly longer than broad, with the wing-covers of a dull-red color with black spots, as shown in the figure. The thorax is black, and the whole dorsal surface is covered with white pubescence. The underside of the insect is also reddish, and the legs are black with a reddish tinge toward tips. We must leave its determination to future correspondence with European specialists.

True Parasites.—The only true parasite of the Fluted Scale yet found in Australia is the now well-known *Lestophonus iceryæ* Williston, first discovered by Mr. Crawford, of Adelaide, and by him sent in small numbers to this country. It is a small two-winged fly, a little over 1^{mm} long and of a deep shining blue and green color. The fly lays her eggs upon the body of the scale-insect. The larvæ live within the body of their host, a large number in one female Icerya, and upon reaching full growth issue through small holes. As many as eleven of the flies have been seen to emerge from one female Icerya. The insect was first noticed by Mr. Crawford in 1886. He was studying a colony of Icerya in his garden, and every individual was destroyed by this parasite. He sent specimens to Miss Ormerod in December, 1886, and wrote to us about it in February, 1887. Miss Ormerod forwarded some of the specimens received by her to us, but they were badly damaged, and it was not until the early summer of 1888 that we received perfect specimens fit for description, although Mr. Crawford had meantime written us several letters and had sent drawings and other specimens. The complete description of the insect, with the figure which we have reproduced upon Plate XI, fig. 2, were first published in INSECT LIFE for July, 1888 (Vol. I, No. 1, p. 21). The genus is a new one, and the insect belongs to the subfamily *Oscininæ*, other species of which are enemies to the grain-grower.

The Lestophonus is not confined, however, to Icerya. Mr. Crawford reared the same parasite from a large, undescribed Coccid of the genus Monophlœbus, which has since been described by Mr. Maskell, in honor of its discoverer, as *Monophlœbus crawfordi*. This large bark-louse supports a greater number of parasites than does the Icerya, and in one specimen seventeen holes have been counted from which the Lestophoni emerged.

THE IMPORTATION OF PARASITES AND PREDACEOUS INSECTS FROM AUSTRALIA.

In our 1886 report it will be remembered that we laid some stress upon the benefit which might be derived from the importation of parasites from Australia to California, basing our argument upon the fact that the two most destructive scales in California were evidently of Australian origin. We stated that there was no way in which the Department could more advantageously expend $1,000 than by sending an agent to Australia to study the parasites of the species there, and to secure them and transport them to the Pacific coast. This statement was repeated with some elaboration in our address before the California State Board of Horticulture, at Riverside, in April, 1887 (see Bulletin 15 of this Division, p. 25). In February, as before stated, we received word from Mr Crawford, of Adelaide, of the important Dipterous parasite, and mentioned its occurrence in our article in the *Pacific Rural Press* of June 11, 1887, on the Origin of Icerya.

We were absent in Europe during the summer of 1887, and during that time specimens were received at Washington from Mr. Crawford; and Mr. Howard, in obedience to our expressed wish, wrote requesting him to endeavor to send living specimens to Mr. Coquillett, in Los Angeles, in order to attempt to acclimate the species. Meantime, and subsequent to our reprint of Mr. Crawford's letter in the *Pacific Rural Press* of June 11, as we have since learned, Mr. Klee, of California, also wrote to Mr. Crawford for specimens. In response to these requests Mr. Crawford very generously devoted considerable time and trouble to the matter, and was able to secure through his personal efforts a number of infested specimens of both Icerya and Monophlœbus, which were forwarded to Messrs. Coquillett and Klee. The specimens which came to Mr. Klee were by him turned over to our other California agent, Mr. Koebele, and both Mr. Coquillett and Mr. Koebele endeavored to isolate the infested Australian scales under covered orange trees infested with Icerya, In both cases a few specimens of the Lestophonus issued under cover, but so far as we have been able to learn no evidence of oviposition or propagation by these confined individuals has been observed.

It was evident that experiments upon so small a scale as this would have by no means the same chance for success that an importation conducted upon a very much larger scale would have, and we endeavored to find some means of securing the funds for the purpose of sending an agent to Australia. A clause in the bill appropriating for the Department of Agriculture prohibited the payment of traveling expenses outside of the United States, and it seemed for a time as though there could be no method of bringing about the desired results except by popular subscription among the orange-growers of California, and such a movement was in fact started. Meantime resolutions were passed by various organizations of horticulturists in

California requesting the California representatives in Congress to endeavor to secure legislation here which would enable the sending of an agent at Government expense, and a strong effort was indeed made in this direction, principally by the Hon. C. N. Felton. These efforts were, however, unsuccessful both as to securing a specific appropriation for this purpose and as to the removal of the restricting clause respecting foreign travel in the appropriation bill of this Department. Fortunately, however, through the kindness of the Secretary of State, we were at last enabled to bring about the desired result through the fund appropriated by Congress for the representation of this country at the Melbourne Exposition. This fund was placed at the disposal of the Secretary of State, and the exigency of this parasite expedition was brought to his attention and his consent was obtained to the sending of an agent particularly for the purpose of studying and collecting the parasites of Icerya. Accordingly Mr. Albert Koebele, who had for some time been stationed in California, and who was thoroughly familiar with all the phases of the investigation of the Fluted Scale, received full instructions and sailed on the steamer of August 20 for Australia.

It is almost too early to express any definite opinion as to the results of Mr. Koebele's mission. That he has been most industrious, and that he has been successful beyond our hopes in collecting scale-insects infested by the Lestophonus, may be stated without reserve. The parasites received have been carefully handled by Mr. Coquillett—many of them reared and liberated. They are at work and multiplying, and the outlook at present is most favorable.

We fully expect to learn of the increase and rapid spread of this new introduction as well as of some of the other predaceous species which have been introduced, and to find that in a comparatively few years the orange groves of southern California will be kept measurably freed of the pernicious Fluted Scale without so great an effort on the part of the growers or so great expense in destroying it. That nature will, with the new conditions induced by these importations, come to the relief of the fruit-grower and that this interesting experiment will result in the ultimate saving of untold millions to the people of the Pacific coast is our sincere belief which we hope to live to see verified. Not that we expect the Icerya to be ever entirely exterminated; but it will be kept under subjection so as to be comparatively harmless, as it is in its native country.

Mr. Koebele's first letter describing his efforts we quote in full:

So far my work has been much more successful than I expected. I not only found the dipterous parasite within Icerya in large numbers, but also three predaceous larvæ feeding upon the eggs of Icerya. One of these is a Chrysopa larva, which I first discovered in numbers, it having almost destroyed all the eggs of the infested Icerya at Mannam, 28 miles up the Murray River from Murray Bridge Station, South Australia; the others are larvæ of a small Coccinella. I have collected and sent with this steamer, *Mariposa*, probably 10,000 Iceryæ, of which at least 50 per cent. are infested with the dipterous larvæ and pupæ. Dr. Schomburg, director of the Botanical Gardens of Adelaide, kindly furnished me with a Wardian case, in which I placed three young orange trees and nine of Pittosporum, securely packed down. The Iceryæ were placed in this on sticks of orange placed in earth, so the smaller, half-grown insects can easily crawl up on the fresh plants, and the flies that hatch en route may be able to go on breeding. Beside these, I send a large lot in tin and wooden boxes, chiefly taken off of twigs; these latter I have placed in ice-box, so that none will be able to hatch during the voyage. As it looks now—for all are on steamer already—the latter experiment will be the best to follow. Notwithstanding the care and labor I have spent in getting this case here in such condition, I fear that the packages will suffer greatly through the handling of the steamer hands. However it may be, I assure you that success will attend your

effort, and I expect to land several thousands of flies in pupa state with every steamer landing at San Francisco.

In regard to the case with plants, this is a bulky thing, weighing 240 pounds, while the same number of scales packed in boxes would make only a few pounds.

The most difficult matter is to get Iceryæ in such large numbers. As yet I have found them only in private gardens, but I know of sufficient for another sending.

On coming on here I also discovered the flies within Iceryæ in Victoria, and am certain that they will be found all over Australia, or wherever Icerya is present.

They are not only parasitic upon Monophlœbus and Icerya, but, I am almost certain, also upon Dactylopius. I found many empty puparia within dried-up Dactylopius, and also have several fresh ones at Adelaide.

Will remain in New South Wales for about a week or so and make a careful examination of the ground, then proceed to Victoria in search of Icerya, but will be in Adelaide in time to make up a larger shipment.

This shipment was received by Mr. Coquillett, at Los Angeles, in the best of conditions. A tent had been placed around an orange tree in anticipation of the arrival of the parasites. The boxes were taken inside the tent and opened. Within a few days 60 specimens of Lestophonus has issued. In the Wardian case of living plants were found living Chrysopa adults, and two species of Coccinellid larvæ, and also many eggs and cocoons of Chrysopa. The Coccinellid larvæ were found crawling outside the case, from which they had emerged through cracks in the putty. When transferred to the orange tree they attacked the first Icerya they caught. The arrangement for propagating the parasites is shown at Plate VIII. The tree under the tent is abundantly infested with Icerya, and the parasites, on issuing, find the conditions almost perfectly normal.

The December steamer from Australia brought Mr. Koebele's second lot of Australian parasites of the Cottony Cushion-scale. Mr. Koebele had informed us by letter that he had forwarded in this lot at least 12,000 healthy living parasites, mostly in the pupa state, and we had every hope that they would arrive in as good shape as the first lot. We were much disappointed, therefore, to learn from Mr. Coquillett that the shipment reached him in very poor condition on December 9, three days after the publication of a letter from Mr. Koebele to Mr. Klee which came on the same steamer. Mr. Klee had some difficulty in getting the boxes from the custom-house, and wrote Mr. Coquillett that "when he got them the boxes were all broken up and had evidently been repacked since Koebele packed them for shipment." When Mr. Coquillett received them there were eight tin and two wooden boxes; "all of the tin boxes were mashed flat and their contents were very moldy." There was in them only one living Lestophonus and one of its parasites, one Coccinellid beetle, and a Chrysopa larva. One of the wooden boxes had also been broken open. Mr. Klee, writing later, explained that the ice in the ice-house, in which the boxes were confined, had fallen upon the packages and smashed some or most of them. It was several days before he could obtain them from the steamer, and the contents of those boxes which were partly open were covered with mold. He repacked and forwarded them as soon as he could.

The accident of the falling ice it was, perhaps, impossible to avoid, although carelessness on the part of the steamer hands might have been at the bottom of it. The delay on the part of the custom-house authorities, however, was no accident, and we at once took steps to prevent its recurrence. The Secretary of the Treasury very courteously issued an order to the collector of the port at San Francisco to allow future packages to enter free of duties and charges, and to forward them unopened and without unnecessary delay to Mr. Coquillett.

January 24 another small consignment was received at Los Angeles from Mr. Koebele. These were not brought over on ice, and the contents of the boxes were in good condition, not being moldy. There were about 50 living *Lestophonus iceryæ*, 30 adults and 18 pupæ of the red and black Coccinellid previously described, and 28 adults and 20 larvæ of another species of Lady-bird.

On January 24 careful examination of the Fluted Scales under the experimental tent showed one female Icerya, whose body was noticeably swollen, as if infested by Lestophonus larvæ. As only two months had elapsed since the first introduction of the Lestophonus into the tent, it was then too soon for any of the larvæ issuing from eggs laid by females under the tent to have completed their transformations. The finding of this single female is a very encouraging sign.

A secondary Parasite found.—We were much disappointed, although not surprised, to learn from Mr. Koebele's December letter that he had discovered a parasite of the Lestophonus. It was rather to be expected that the primary Dipterous parasite would have its enemies, but it was none the less a discouraging thing to learn that there really was one. Mr. Koebele sent a series of pinned specimens to us direct from Australia, and Mr. Coquillett also forwarded a series which he secured from Mr. Koebele's second sending of the primary parasites. This secondary parasite is a very strange form, and is illustrated at Plate IX, fig. 2. It is a new and remarkable genus of the peculiar Chalcid subfamily *Elasminæ*, and we shall describe it in a near number of INSECT LIFE under the name *Euryischia lestophoni*, by which name it may now be called. Mr. Coquillett was on his guard against this parasite, and has up to the present time exercised such care that not one has escaped.

REMEDIES.

The conclusions at which we arrived in our 1886 report are, in the main, the opinions which we hold to-day relative to the remedies for Icerya. We still have the same distrust of strong caustic remedies, and still hold to our conclusions respecting the value of the washes, of which the kerosene-soap emulsion is the base. In our report for 1887 we published an account of some additional experiments by Mr. Koebele, in which the principal feature is to the effect that the addition of arsenious acid in one form or another to kerosene emulsified with resin compound is of value, as we prophesied in our Riverside address in April, 1887. Mr. Coquillett, under instructions from this office, has conducted most careful and extensive experiments with the gas treatment, and in our report for last year some twenty pages are devoted to his report. We also in that report figure three styles of tents which are used in California for inclosing trees and confining the gas used.

During the summer of 1888 he conducted further experiments in this direction, and has summarized in his report for the season, which will be found under the head of "Reports from Agents," not only his own experiments, but those of others, and has given us a good insight into the present status of the gas treatment. It seems to be coming into more general use, and is giving fairly good satisfaction. A company has been organized for the purpose of operating the Culver fumigator, figured upon Plate IV of the 1887 report, and several private individuals are rigging up fumigators of their own planning.

The making of one of these tents is, however, a very expensive thing, and the application of gas itself is also costly. In fact, we see no reason for revising the opinion which we have already published in the December number of INSECT LIFE, that thorough and persistent work with any one of a half dozen of the kerosene and resin compounds will prove more satisfactory and less expensive than the fumigating process, especially on young trees or where they are taken in time. The experiments made by Mr. Koebele in 1886 and 1887 demonstrated the efficacy of certain of these washes to our entire satisfaction, and we fail to understand the general discouragement among many of the orange-growers, except upon the ground that our previous utterances have not attracted their attention, or upon the ground that such experiments as they have made have not been thorough, or have been made under disadvantages.

It may be well in this connection to state that we have been informed from California correspondents that the Culver-Keach Fumigating Company is claiming the patent right not only to their fumigating tent and apparatus, but to the process of fumigation. We are informed by the Patent Office that no such patent has been issued to this company, and that the so-called Hatch patent having expired no patent can be issued for this process.

THE HOP PLANT-LOUSE.

(*Phorodon humuli* Schrank.)

Order HOMOPTERA; family APHIDIDÆ.

[Plates II, III, IV, and VII.]

INTRODUCTION.

During the summer of 1883 we were first able to pay some attention personally to the subject of insects affecting the Hop, and in the summer of that year we also had an agent, Mr. J. B. Smith, visit the hop yards in the neighborhood of Herkimer, Waterville, and Cooperstown, N. Y. The results of his investigations were published in Bulletin No. 4 of this Division, and his report deals chiefly with hop insects other than the Phorodon, although this species received some attention. Mr. Smith was, however, unable to add any authoritative facts on some of the more interesting points yet in dispute, especially that of hibernation and migration.

The testimony on this point was, owing to the limitation of time which he could give to the matter, for the most part at second hand, *i. e.*, from the more reliable hop-growers whom he could consult, and his conclusions drawn therefrom, as subsequent evidence proved, were misleading. The fact, however, that he was unable to definitely ascertain the winter habitat of the species in endeavors to find it in hop yards is all confirmatory of the facts subsequently proved, as will herein appear.

During the summer of 1886 this insect was enormously prevalent through all the hop-growing regions of New York and Wisconsin. The damage was very great, and prices of hops of the previous year doubled and trebled. American hops were purchased in England and reshipped to America. We were absent in Europe at the time, but immediately upon our return to this country we commenced an

investigation, which was actively carried on through the season of 1887 and resumed again in the spring of 1888, resulting in the accurate establishment beyond all doubt of the facts in the life history of this insect which had previously been in dispute, as also of other species which affect the crop. We shall publish in a special bulletin the detailed results of the investigation, and present here, in summarized form, the facts relating to the life history of the Hop Phorodon only. We have added to this summary a report by one of our assistants, Mr. W. B. Alwood, on remedies to be used against the insect and based on the experiments which we had planned, and which he had in charge, during the summer of 1887 at Richfield Springs.

These experiments, summarized by Mr. Alwood, were made only in the summer upon the hop plant; while, as will appear from our account of the life round of the insect, it can be attacked under more favorable conditions and with preventive results at another season and in another place.

REVIEW OF THE LITERATURE.

One of the earliest, if not the earliest, recorded writings on the Hop Aphis is an article by J. G. Orth (1752), entitled "Betrachtungen über die Neffen im Kraute und die kleinen Insekten, welche den Hopfen verderben." We have not seen the article in question, but give it on the authority of Hagen (Biblioth. Ent., p. 22).

The earliest scientific description of *Aphis* (*Phorodon*) *humuli* occurs in the Fauna Boica, by Franz von Paula Schrank, 1801, Vol. II, p. 110, where the following characterization is given:

Whitish-green, unicolorous; two little horns at the anterior end; antennæ at base with a tooth.

Aphis humuli.

Habitat: On the underside of the hop leaves.

NOTE.—The honey-tubes nearly parallel, a little inwardly inclined.

This is the mildew of the hop; in fact an indication that the plant is diseased, but not the cause of the disease.*

Kirby and Spence, in their Introduction to Entomology, fourth edition, 1822, Vol. I, p. 183, refer to the presence of the Hop Aphis in South England in 1807, and more particularly to the very great numbers of Coccinella species, the larva of which preys on the insect in question.

An article by Rev. F. W. Hope (Trans. Ent. Soc., London, 1835) discussing methods of preventing the ravage of the Hop-fly, deserves mention only to point out the singular batch of errors which it contains. Among others, he supposed that the flies or embryos passed the winter on the poles, and hence advised the use of new poles, or the charring of old ones or dipping them in corrosive sublimate, etc.

In 1843, J. H. Kaltenbach (Monographie der Familien der Pflanzenläuse, pp. 36, 37), describes the wingless and winged forms of *Aphis humuli*, and he states that the species appears to be rare on other food plants, but that he has found it on the Sloe (*Pyrus spinosa*).

*Hopfen B., 1199. Weisslichtgrün, einfarbig; zwey Hörnerchen am Vorderende; die Fühlhörner am Grunde mit einem Zahne.

Aphis Humuli.

Wohnort: An der Unterseite Hopfenblätter.

Anm.—Die Saftspitzen fast parallel, ein wenig einwärts geneigt.

Dies ist der Mehlthau des Hopfens; in der That eine Anzeige, dass der Stock krank sey, aber nicht die Ursache der Krankheit.

Francis Walker, in the *Zoölogist* of 1846, Vol. IV, p. 1461, gives a very good description of young and winged females, making no mention, however, of the frontal tubercles. He states that the aphides are most abundant in hot seasons, and recommends a change of soil and burning of poles every year.

In the Annals and Magazine of Natural History for 1848, Vol. I, second series, pp. 372 and 373, Mr. Walker published a very interesting article entitled "Remarks on the Migrations of Aphids," which seems to have been very generally overlooked of late. In this article Mr. Walker makes the statement for the first time that the Hop Plant-louse "lives permanently and aboriginally on the Sloe, and the hop grounds now provide it with a plentiful provision in the summer." He goes on to say that its abundance upon the Hop is dependent upon the proximity of the Sloe to the hop yards, and that investigations should be made on the abundance of the sloes in the vicinity of hop yards and the length of flight of the Hop-louse, in order that in time all sloes may be removed sufficiently far from the hop yards to confine the lice to the former plant.

Mr. Walker's paper attracted some attention at that time, as is shown by the mention made of it in Mr. William Spence's address as president of the Entomological Society of London, delivered January 22, 1849, and printed in part in the Annals and Magazine of Natural History for April, 1849. Mr. Spence spoke of Mr. Walker's observations in a eulogistic manner, and anticipated the entire freedom of the hop yards from this insect as a result of the discovery, stating that it is only necessary to destroy all the sloe trees in the neighborhood of a hop yard.

Both Mr. Walker's communication and Mr. Spence's address were known to Dr. F. Plomley, who, probably as a result of these communications, made certain original observations which are reported in a lecture on "Blights, Aphids, etc., including the Hop-fly and its Enemies," delivered before the Weald of Kent Farmers' Club, July 4, 1849. This lecture was printed in the *Maidstone Journal* of July, 1849, and we have recently been able to secure, through the kindness of Mr. Richard Cook, a manuscript copy of this rare article. Dr. Plomley corroborated Mr. Walker's observations and actually transferred Aphids from the Sloe to the Hop and predicted the time of their appearance upon the hop vines. He objected to Mr. Spence's conclusions, however, on account of a lack of knowledge as to the extent of the flight of the Aphids, imagining that they might fly very great distances. He also supposes that other species of Prunus allied to the Sloe might supply winter quarters. An extract from this lecture is published in Morton's Cyclopedia of Agriculture, 1855, in an article on the Hop, by J. M. Paine, and from this source Fitch (1865) obtained his knowledge of Plomley's observations.

In 1857, C. L. Koch describes and figures some of the forms and records the migration of the Hop Aphis as follows: "Found in the last days of May on the young shoots and on the underside of the leaves of *Prunus domestica, insititia*, and *spinosa;* migrates in June to the underside of the leaves of the wild and cultivated hops."

The *Rural New Yorker* of October 10, 1863, on the authority of Mr. Walsh (*Practical Entomologist*, II, p. 41), contains the statement that the Hop Aphis made its first appearance in Oneida and Madison Counties, New York, in the year 1863.

Dr. Asa Fitch, in his Tenth Report, Insects of New York, 1864, discusses the Hop Aphis at some length, quoting its life history from

Paine's article in Morton's Cyclopedia. He states that the lice made their appearance suddenly two years previous [1862 (?)],* explains the honey dew, mentions natural enemies, recommends crushing by hand, syringing with soap-suds, and fumigating with tobacco smoke. He, however, makes no mention of any migration.

In the *Country Gentleman* of August 3, 1865, Fitch reproduces Plomley's statements, already given, and observes that the *Aphis pruni-mahaleb* has been proved to be identical with *humuli*, and inclines to accept the migration theory. (*Cf.* Lintner, in First Report New York State Entomologist.)

In the *Country Gentleman* of April 27, of the same year (again on the authority of Lintner), Fitch, in an article on the Hop Aphis, states that the species was first observed in America two years before (1863).

A number of newspaper articles of minor importance appeared in the two or three years following, republishing remedies and old accounts of habits, but adding no new facts to the life history.

F. Walker, in the *Zoölogist* (London), second series, 1868, gives a translation of Passerini's systematic arrangement of Aphidæ, and on page 1053 gives the table of Phorodon, including *Ph. humuli*. In the note to this species, Mr. Walker says that its history is still incomplete; "it migrates from the sloe to the hop and dwells there awhile and is called the Hop-fly, and then returns to the sloe."

Buckton, 1876, Monograph of the British Aphides, Vol. I, p. 73, reproduces without comment Walker's statement regarding the migration of *Ph. humuli*, and quotes Walker as authority for the identity of *Ph. humuli* with *Aphis* (*Phorodon*) *mahaleb*. He gives Passerini's dissenting opinion, however, and inclines to believe that the latter species is only a variety of the former. The apterous viviparous female and the winged viviparous female of *Ph. humuli*, var. *mahaleb* (?), are described on pages 168, 169.

Cyrus Thomas, Bull. No. 2, Ill. State Laboratory of Nat. Hist., 1878, p. 9, gives a diagnosis of the genus Phorodon, and simply catalogues *Ph. humuli* with *Ph. pruni-mahaleb* as a synonym, adding, "the well-known and injurious Aphis of the Hop vine; the cause of the 'Blight.'"

Again, in his Third Report on the Insects of Illinois (8th in series 1879), Thomas gives a description (p. 69) of *Ph. humuli* (quoting from others its life history and habit); and on page 72 describes *Ph. humuli* var. *mahaleb* and refers to it as being common in May and June on the Sloe. In the description of both forms nothing whatever is said of the migration of the Hop-louse.

In 1881 (*Am. Nat.*, XV, pp. 819, 820) we discussed Lichtenstein's communication on the migration of Aphids from one plant to another, and spoke in this connection of *Ph. humuli*.

J. Lichtenstein, remarking on Buckton's British Aphides in the *Entomologist's Monthly Magazine*, Sept., 1883, pp. 79, 81, expresses his astonishment that Buckton did not try to follow *Ph. humuli* from the Plum to the Hop, and states that he has succeeded himself in transplanting the species from the Plum to the Hop. *Phorodon mahaleb* he considers to be merely a different stage of development of *Ph. humuli*.

One of the most elaborate articles published on the subject, and one of the first to view it from an economic side, was that given by

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*Probably 1863, as the report was not published till 1865.

Miss Ormerod in her report for the year 1885 (London, 1885). Miss Ormerod, in this article, which is printed upon pages 43 to 56 of said report, reviews the literature and devotes much space to the consideration of remedies, and concludes that the insect hibernates at the roots of the Hop, as well as upon Damson and Sloe, and that the summer attack originates both from wingless females, which go up from the ground, and from winged females, which fly in from the other trees. Upon this belief she bases certain remedial measures in the way of treating the ground about the Hop plants in the late fall for the destruction of those individuals which hibernate upon the roots; and her article no doubt largely contributed to the very general wrong impression. Miss Ormerod's conclusions were not founded upon her observation of Phorodon hibernating in this location, but were founded upon hearsay. We have thus commented on her conclusions in a paper read at the meeting of the British Association for the Advancement of Science, at Manchester, September 3, 1887:

"So far as her own careful observations are concerned they fully accord with the facts here set forth; but on the authority of others, and especially on the evidence of Mr. C. Whitehead, who reported finding young lice and large viviparous females on hop shoots as early as March 29, and that of Mr. A. Ward, who experimented with surface dressings near Hereford, Miss Ormerod concludes that attack on the Hop begins in spring from wingless females which come up from the hop hills, and, as a corollary, that dressings to prevent such ascent are strongly to be recommended. It is quite within the range of possibility, and what is known of aphid life, that where the winters are mild, with scarcely any frost, this Phorodon may continue on the Hop from one year to another in the parthenogenetic condition. If such is ever the case in England you have a somewhat different set of facts to deal with here from what we have in America. But for the reasons already stated in abstract, from many other detailed observations which it would be tedious to record here, as well as from the ease with which erroneous conclusions are arrived at in entomological matters of this kind where not checked and proved by the most competent and careful study, I shall be inclined to believe that the facts in England are essentially the same as I have found them in America, until convincing and trustworthy evidence to the contrary be forthcoming. Mr. Whitehead may have had another species under observation, and Mr. Ward's surface dressings may have acted by repelling the winged female migrating from Prunus in the same way that buckwheat sown among the hops is believed to do with us."

The next year (1886) Mr. Charles Whitehead published a report on insects injurious to Hop plants (London, 1885), under the Agricultural Department of the Privy Council Office. This is a pamphlet of some thirty pages, and his conclusion respecting hibernation is that "the Aphid deposits its eggs in the ground hard by the hop plants or upon the short pieces of bine that are left upon the Hop stock and upon the bines that are subsequently carried away for litter."

Immediately upon our return from Europe in the fall of 1886 we visited the Hop yards around Richfield Springs and published a note in the *Richfield Springs Mercury* for September 20 announcing the discovery of the winter eggs on the Plum and giving a brief account of our ideas as to the life history of the pest. A number of newspaper articles were published during the winter, as was natural from

the great damage done in the summer of 1886, and some dissent from our views was expressed.

Dr. J. A. Lintner, in the *Country Gentleman* for May 19, 1887, announced the discovery of an Aphid at the roots of the Hop vine in Oneida County. He determined it as belonging to the Rhizobiidæ, and stated that it was not impossible that this insect might develop into the Hop-louse, and that in his opinion the existence of a winter generation upon roots was not incompatible with the hibernation of a portion of the brood in the egg state on the Plum trees.

In the Waterville *Times and Reflex* for June 17, 1887, we gave an account of the settling of the Hop yards by the lice from Plums and discussed Mr. Lintner's article showing that the insect found upon the roots was a Pemphiginid, probably of the genus Schizoneura, and that it was impossible for this insect to develop into a Phorodon. This article was a lengthy one and attracted considerable attention, and our views as to the hibernation upon Plum and the migration to and from Hop were attacked by several writers, notably E. P. Powell, in the *Rural New Yorker*, and a writer signing simply the initials "J. F.," in the *Country Gentleman*. The latter writer, in an article published August 18, 1887, quotes extensively from Mr. Smith's report in Bulletin 4, previously referred to, in support of his view that the lice hibernate at the roots of the Hop, and this naturally called forth an article from Mr. Smith, which was published in the *Country Gentleman* two weeks later, in which he denied special knowledge of the subject and stated that his conclusions were based upon hearsay. He also expressed his agreement with our later conclusions.

At the meeting of the Society for the Promotion of Agricultural Science held in New York in August, 1887, we read a paper giving the results of our investigations up to that time, carrying the life history of the insect down to the ninth generation. This paper was printed in full in the Proceedings of the Society.

September 2, 1887, we read a paper before the British Association for the Advancement of Science, at Manchester, England, in which we covered much the same ground. In the *Gardener's Chronicle* for October 22, 1887, we gave an account of the concluding observations of the season as made by us in the Hop yards in the vicinity of Maidstone, England, and reviewed the entire life history of the insect, suggesting remedies and calling attention to the previous differences of opinion regarding the relationship between the Hop Phorodon and the form upon Prunus.

November 17, 1887, Mr. Howard, in an extended article in the *Country Gentleman*, recorded, at our instance, the facts obtained by our assistants in the hop fields of central New York subsequent to August 1, completing the life round in America and quoting from letters received from us the results of our parallel observations in England.

In March, 1888, we read a paper before the Philosophical Society of Washington entitled "Some Recent Entomological Matters of International Concern," in which we also gave a summary of the results of the investigation. This paper was published with illustrations in INSECT LIFE for November, 1888. In addition, we read in August, 1888, before the Society for the Promotion of Agricultural Science at the Cleveland (Ohio) meeting, a paper entitled "Further Notes upon the Hop Plant-louse," which supplemented that read at the 1887 meeting in New York and which is published in the Proceedings of the Society for 1888, pages 55 to 59.

It is evident, from this review of the literature, that while the fact of the migration was insisted upon as early as 1848 (although the exact details of the observations made by Walker are nowhere given), the fact was considered as subject to strong doubt, and was discussed as an open question by all writers subsequent to the paper of Koch referred to above. The only accurate records of observations published up to the time of our own are those briefly mentioned by Dr. Plomley in his lecture, and these have seldom been referred to since. It was in this position of disputation and great doubt as to the actual facts that we began our investigation. We were unfamiliar with Dr. Plomley's rare lecture until last summer, after our investigation had been entirely completed; and while we must confess that this writer arrived at a very accurate view of the facts, so far as his observations went, the extended and full observations which we have carried on were none the less necessary to settle, not only the one great mooted point of mode of hibernation, but also to set forth upon incontrovertible facts, based on careful observation, the full life cycle of the species.

LIFE HISTORY.

Of the summaries which we have already published and which are mentioned in the preceding review of the literature, that printed in INSECT LIFE is well adapted to our present purpose, and we here reprint it with slight change:

I have for some years desired to settle a question that has been mooted among entomologists, as also among hop-growers, viz, the mode of hibernation of the species; for while some of the earliest writers upon aphidology have believed, and even stated, that there was a form of this insect that occurred in autumn on the Damson in Europe, the statement has been as confidently controverted and the fact denied by some of the highest authorities in the family. Hop-growers as a class have generally pooh-poohed the idea. Yet, from my own experience with other species of the family and with their singular life history and migrations from one plant to another, I had for some time felt convinced that *Phorodon humuli* also must have some other winter resting place than the hop vine, and after very careful and persistent investigation, in which I have had the co-operation of several of my assistants, the question has been fully and thoroughly settled.

The facts in the life history of this insect, therefore, may be summed up as follows: Hibernating at the present season of the year, the little glossy, black, ovoid eggs of the species are found attached to the terminal twigs, and especially in the more or less protected crevices around the buds, of different varieties and species of Prunus, both wild and cultivated. From this winter-egg there hatches a stem-mother (Plate II, Fig. 2), which is characterized by being somewhat stouter, with shorter legs and honey tubes than in the individuals of any other generation.

Three parthenogenetic generations are produced upon Prunus, the third becoming winged (Plate II, Fig. 4). This last is what my late friend Lichtenstein called the *pseudogyna* or migrant, and it instinctively flies to the hop plant, which is entirely free from attack during the development of the three generations upon Plum. A number of parthenogenetic generations are produced upon the Hop until in autumn, and particularly during the month of September winged females are again produced. This is the *pupifera* of Lichtenstein or return migrant, and she instinctively returns to the Plum. Here she at once settles and in the course of a few days, according as the weather permits, produces some three or more young. These are destined never to become winged and are true sexual females (Plate IV, Figs. 4 and 5). Somewhat later, on the Hop, the true winged male (Plate IV, Figs. 2 and 3), the only male of the whole series, is developed, and these males also congregate upon the Plum, on the leaves of which toward the end of the season they may be found pairing with the wingless females, which stock the twigs with the winter-eggs (Plate II, Fig. 1, and Plate IV, Fig. 6). Such, briefly, is the life history. Twelve generations may be produced during the year, but there is great irregularity in the development of these generations and the return migrant from the Hop is produced at the end of the season whether from individuals of the fourth or fifth

generation, or of the twelfth. As I have remarked elsewhere* "each partheno-genetic female is capable of producing on an average one hundred young (the stem-mother probably being more prolific), at the rate of one to six, or an average of three per day, under favorable conditions. Each generation begins to breed about the eighth day after birth, so that the issue from a single individual easily runs up, in the course of the summer, to trillions. The number of leaves (seven hundred hills, each with two poles and two vines) to an acre of hops, as grown in the United States, will not, on the average, much exceed a million before the period of blooming or burning; so that the issue from a single stem-mother may, under favoring circumstances, blight hundreds of acres in the course of two or three months.

"While meteorological conditions may materially affect the increase and power for injury of the species, these are far more truly predetermined and influenced by its natural enemies, many of which have been studied and will be described.

"The slight colorational differences, as also the structural differences, including the variation in the tubercles or cornicles on head and basal joints of antennæ, whether upon Plum or Hop, are peculiarities of brood and have no specific importance whatever.

"The exact knowledge thus gained simplifies the protection of the hop plant from Phorodon attack. Preventive measures should consist in destroying the insect on Plum in early spring where the cultivation of this fruit is desired, and the extermination of the wild trees in the woods wherever the hop interest is paramount; also in avoiding the introduction of the pest into new hop countries in the egg state upon plum cuttings or cions. Direct treatment is simplified by the fact that the careful grower is independent of slovenly neighbors, infection from one hop yard to another not taking place.

"The bearing of these facts will probably best be brought home by the statement that hitherto hop-growers have been groping in the dark and working to prevent injury by applications to the soil. In fact, the English hop-growers have been led by their very best authorities to waste their energies in this direction. The importance of the matter will appear when I state that the hop crop, which is quite an important one in some parts of this country, and especially important in some parts of Europe, annually suffers from the ravages of this, its worst insect enemy, and some years is rendered a total failure by it. Further, that some parts of this country, as the Pacific coast, are yet free from it and that hop-growers there by being forewarned may prevent its introduction from the East or from Europe, as there is very little doubt in my mind but that the insect has been introduced from one country to another in the egg state upon Plum scions, as it may easily be transported from place to place in this manner. I had the pleasure during September and the early part of last October to finish up the investigation and follow out the closing scenes in the life history of this species in the county of Kent, England, while some of my assistants were doing the same thing in Herkimer County, N. Y., and the facts independently obtained correspond in a remarkable manner, thus confirming and strengthening the conclusion which I have indicated to you."

The round of the insect's life is thus perfectly plain, and the principal facts ascertained during the year 1887 and the spring of 1888 are thus briefly summarized in our communication to the Society for the Promotion of Agricultural Science, already alluded to:

1. The insects begin getting wings in autumn irrespective of generation. These winged females may either come from the fifth generation of the year or as high as the thirteenth, thirteen generations having been followed during the year 1887.

2. The males uniformly appear after the females and after the hop crop is harvested. Hence it becomes extremely important to destroy by fire or by thorough drenching with a strong kerosene emulsion all the hop vines as soon as possible after the crop is harvested. This would cut off the larger bulk of the males so that there would be little or no impregnation of the sexual females, which are for the most part at that time already on the Plum.

Another interesting fact is worthy of record here; it is the small proportion of eggs which survive the winter. In the fields and orchards where my observations were made in England some trees were literally covered with eggs, and I brought a number of them with me to this country. The same was true of the plum trees in New York which were under observation by my assistants. Some of them were literally covered with winter eggs. I watched them carefully not only by means of those brought with me from England, but of others brought from New York in the late fall or early winter, and still other specimens repeatedly received during the

* Paper read before the British Association, Manchester, September 2, 1887.

winter from Richfield Springs. As the hatching period approached I was quite surprised to find how many of the eggs shriveled up and perished. I also made it a point to be on the spot as soon as vegetation began at Richfield Springs and found there, in a state of nature, the same mortality among the eggs. The large majority of them that had escaped natural enemies had perished by shrinking and shriveling. Again, the stem-mothers which hatched on Plum last spring, though they were few compared with the number of eggs that had been provided, were for the most part lost through storms or the working of natural enemies, so that a very small proportion succeeded in developing. A number of additional interesting details of an entomological character have been obtained since the last meeting of the society, but they will be brought together in a forthcoming bulletin from the Department of Agriculture.

The whole record has been rendered the more difficult by virtue of the occurrence of a very closely allied species (*Phorodon mahaleb*) which, though hatching at the same time as, and very similar to, *humuli*, does not migrate to the Hop, but goes to various other plants of no importance in cultivation.

We have shown upon Plates II, III, and IV the principal stages of the insect in its different generations, and particular description in this connection is not necessary.

REMEDIES.

We have indicated in a passage quoted above from our British Association paper that the discoveries just recorded greatly simplify the matter of remedies. Three important facts are patent: (1) It will pay to make a preventive application of some one of the mixtures mentioned further on, with apparatus there described, to all plum trees in the neighborhood of hop yards, either (*a*) in the spring before the appearance of the first winged generation and its consequent migration to Hop, or (*b*) in the Fall after hop-picking and after the lice have once more returned to the Plum and are making their preparations for the laying of winter-eggs. The latter time will, perhaps, be preferable, for the reason that in the Fall the plum trees will be less susceptible to the action of the washes and a stronger solution can be applied without damage to the trees. (2) All wild plum trees in the woods through a hop-growing country should be destroyed. (3) The Hop vines should be either burned or thoroughly drenched with kerosene emulsion as soon after the crop is harvested as possible.

If these measures are carefully followed comparative exemption from lice may confidently be expected.

As to actual summer field work where these precautions have been neglected and where the lice have abundantly infested a given field, we here present a report of a series of experiments made, under direction, by Mr. Alwood, at Richfield Springs, N. Y., during the summer of 1887, and from which it will be seen that it is possible at a comparatively slight cost to spray the yard with a mixture which will destroy the lice without injuring the crop.

It will be noticed that of all the different substances experimented with none gave more satisfaction than properly prepared kerosene emulsions or fish-oil soaps, and that when properly used they are entirely satisfactory. This is very much what we anticipated would be the case. Of a number of other substances experimented with by Mr. Alwood, such as "Australian Garden Wash," "Larvaline," "Buhach" and other brands of Pyrethrum, "Vick's Insect Powder," Sulphuretted Lime-water, and Sulphide of Potassium, no detailed report is given, for the simple reason that they proved impractical on a large scale, and the details of the experiments are omitted for

the sake of brevity. With regard to spraying nozzles the Riley or Cyclone nozzle, with properly adjusted outlet, has every advantage for use at the proper season, *i. e.*, early in the summer when the insects have just begun to spread and before the vines are too tall or when a good deal of under-spraying is necessary; while later in the season when the vines have reached the top of the poles and more force and more direct spray upward are necessary, some more direct end-discharge nozzle like the Climax, giving greater force and volume than can ordinarily be given by the Cyclone nozzle, is better.

REPORT ON EXPERIMENTS WITH REMEDIES AGAINST THE HOP-LOUSE.

By W. B. ALWOOD, Assistant.

LETTER OF SUBMITTAL.

SIR: The following general account of my observations and experiments relating to the Hop Aphis, conducted under your direction, and in part with your personal superintendence in the field, is hereby submitted, accompanied by several papers which give in full detail the results of experiments with insecticides and appliances for using them. I wish to state that the Division is under great obligations to Mr. Springer Goes, who was at the time acting as temporary agent, for the faithful and intelligent assistance he rendered during the work; also to Mr. Martin Goes, on whose premises most of my observations and experiments were made, are due the sincerest thanks of this Division. Nothing could have exceeded the cordiality and good will shown toward the work of the Division during its entire progress. Without a single exception all growers with whom I came in contact were uniformly courteous and willing to aid the Division in its work.

Very respectfully,

WM. B. ALWOOD.

Prof. C. V. RILEY,
U. S. Entomologist.

INSECTICIDES.

No attempt was made to classify and use remedies according to their known or supposed action, but such substances as were considered possible remedies, so far as they could be obtained, were used and the results are here given.

A practical remedy for the Hop-louse or for any injurious insect must answer to the following requirements: (1) It must be cheap; (2) it must be harmless to the plant; (3) it must be effective as a destroying agent. In this special case it is necessary to add another specification, viz, the liquid must spread well over the leaf when sprayed. However deadly a remedy may be, unless it will spread over the leaf it is not possible to make it reach all the lice, hence its effectiveness is lost. Soapy mixtures and emulsions meet this requirement better than anything else I have tried. Cheapness of a remedy is a point of prime importance, and together with the facilities for applying largely determines its usefulness. The matter of machinery and methods of application is specially considered further along in this paper.

I shall endeavor to give an idea of the average cost of the different remedies, that all may intelligently consider the results obtained.

For convenience I will give the following facts as a basis of calculation: There are about 700 hills of hops per acre, and where sprayed when the vines are about half grown 1 pint will spray a hill when applied with proper machinery. This would make an estimate of about 100 gallons of liquid per acre. However, this is only given as an estimate to furnish a basis for calculation when considering the cost of spraying a yard. The actual cost must always depend on circumstances. The tests with the various substances are not given in full, with dates, etc., as this only tends to confusion where so many substances are used, but the results with each substance are condensed into one account.

The experiments were conducted continuously for a period of seven weeks. Every substance which gave any promise of being a practical remedy was repeatedly used until I was satisfied as to its value.

The trials were on a small scale, using only a portion of one plant in each test. Liquids were applied with a bellows atomizer, and the few powders used were applied with powder bellows.

POTASH.

Saturated solution made by boiling and then allowing to cool. This was used strong as foliage would bear (diluted four times), but was of no consequence as a remedy. It spread poorly. Some few were killed, but not enough to make it worthy of trial by farmers. At this strength it contained much more potash than some of the most effective soap solutions.

SODA.

Caustic soda solution prepared as the last was less effective. Diluted one time it was not injurious to the foliage. Evidently it is not practical to use alkalies simply in solution, but, as succeeding tests will show, soaps are effective when diluted so that one pound of condensed lye is distributed through 100 gallons of water. These solutions do not spread nearly as well as soap-suds.

PARIS GREEN.

This was sprayed upon the lice in strength of 1 pound to 50 gallons of water. Like all liquids of this kind it would not spread. Some few lice were killed where immersed under drops of liquid, but not many. This mixture was also used with soaps, but added nothing to their efficacy.

Paris green was used because of its well-known caustic action; however, it is apparently valueless in this case.

ROSE TOBACCO SOAP.

This was sent to the Department by the Rose Manufacturing Company, 17 South William street, New York City. The company give as the ingredients of the soap extract of tobacco reduced to a paste *in vacuo* and then mixed with soap made from cotton-seed and fish oils and sodium sulphide. In wholesale lots it can be bought for 15 cents to 20 cents per pound, depending on whether put up in large or small tins. It is usually offered in the market in half-pound tins. As an insecticide preparation it is not poisonous or unpleasant to handle.

A suds of this was made, using 1 ounce of the soap to 2 quarts of water and kept in jars for the tests.

At this strength it killed effectually, but was a little slow, requiring twenty minutes for full result. It spreads well, but not equal to the best soaps mentioned below.

Diluted 1 ounce to 4 quarts of water it killed quite effectually, but was not sure when diluted more than this. At this rate it requires at least 6 pounds to spray an acre. When used in full strength given above the hops were not injured.

ROSE TOBACCO EXTRACT.

Furnished by the same company. Principal ingredient, extract of tobacco mentioned above. The most noticeable difference is a much stronger odor of tobacco. It was used at the same time and in the same strengths as the last. It does not spread quite so freely as the soap, but kills the lice more effectually. The odor of tobacco is so strong that if used on maturing burs it would doubtless injure their quality. I do not consider this a practical remedy to use by itself for field work, but, from experiments made just at the close of our work, think it very valuable to mix with soap-suds.

TOBACCO DECOCTION NO. 1.

This was made for the work in the following manner:

One pound of Leon Hirsh's Crystal potash lye was dissolved in 1 gallon of soft water, and when brought to a boil 2 pounds of waste from cigar factory were added. After the tobacco had been thoroughly steeped in the boiling lye for a few minutes the whole was set away in a closed vessel to cool. When cool the liquid was strained off. In order to get anything like the original gallon of liquor it requires considerable pressure. This extract was used in different dilutions from five to thirty times its measure of water.

It would not spread well though strong with alkali, and was not a success. Diluted five times it was yet too strong for the foliage. Diluted ten times it could be used with safety and killed effectually when lice were thoroughly wet, but it collects in drops too much for good work. One gallon of the liquor, as made, was worth 60 cents.

TOBACCO DECOCTION NO. 2.

This was made as follows: One pound of tobacco waste was boiled in 1 gallon of water for three hours, filling up to 1 gallon when done.

This was used pure and diluted up to four times. It spread poorly.

Pure, it killed all lice perfectly, but was too strong for the foliage. Diluted four times, it yet kills fairly well, but can not be made to reach all the lice because it will not spread. The liquor at this strength added to soap-suds (made from soap No. 1, to be described further on in this report) gave good results. The combined mixture was as follows: Tobacco extract diluted four times, 1 part; soap-suds (1 ounce soap to 2 quarts water), 2 parts; water, 4 parts.

This mixture gave excellent results, killing almost perfectly. Mixed in the above proportions, considering each part to be 1 gallon, the total mixture, 7 gallons, is worth about 6½ cents.

This is dearer than a mixture should be for general use, although 90 cents to $1 per acre is not an excessive cost for material, and this mixture would not exceed that cost if properly used.

KEROSENE EMULSION.

This was made for the work after the formulæ frequently published by the Division of Entomology. The quantities used for one mixing were oil, 8 pints; water, 4 pints; soap, ½ pound. Soap No. 1 of my own manufacture was used. This gave an excellent emulsion. It was used in various strengths. At ten dilutions, the foliage was immediately blackened and the vine destroyed. At twenty dilutions, the injury to the foliage was scarcely perceptible, yet where vines were thoroughly drenched the indications were that it did slight injury. At twenty-five dilutions it seemed to be perfectly safe.

As a destructive agent for the lice it was quite effective when diluted thirty times. Sometimes a few would not be destroyed, but where thoroughly drenched it was reasonably sure. This strength killed leaf-hoppers and lady-birds (Coccinellidæ) as readily as lice. Above thirty dilutions it was not sure. Even at this strength it left a considerable odor of kerosene on the vines, but this disappeared in a day or so and no injury was apparent to smell or sight. This liquid at twenty-five to thirty dilutions spreads quite well, hardly equal to best soaps, but if finely atomized answers all purposes. From my tests I am of the opinion that it is a practical remedy at these strengths. If any change in proportions of ingredients used is made, it should be in the soap. This may be doubled and would probably add a little to the efficiency.

A common grade of kerosene which is good enough for this work can be bought in most localities for 8 cents per gallon by the barrel, and the soap used can be made for 1 cent per pound. This would make the batch given above cost 8½ cents, and diluted with 25 gallons of water to one of emulsion would make 38½ gallons of wash. At this rate 100 gallons would cost 20 cents, certainly a very reasonable price.

PARAFFINE EMULSION (?).

This was made from a formula in Miss E. A. Ormerod's report (1886) on the Hop-louse in England.

The word paraffine oil is used, and whether meaning commercial paraffine or kerosene is not at all certain. Paraffine is not an oil, but a solid tallowy residue left in the distillation of petroleum oils. The formula given in her report is, soap, 12 pounds; paraffine, ½ gallon; water, 100 gallons. The paraffine and soap were melted and heated to boiling with part of the water, and then added to the balance of the water and all thoroughly churned with a force pump. It made a good suds, but upon cooling the paraffine arose to the surface in small tallowy masses coated with particles of soap. It was in no sense an emulsion. This was made from my best soap, and was a fairly successful wash; but as the effect was solely due to the soap, and as this will be mentioned further on, it is unnecessary to speak further of it here.

A like preparation was made using kerosene instead of paraffine. It was thoroughly churned for fifteen minutes, and for a while it was thought the oil would not

separate, but after two hours it came to the top. The amount of kerosene in such a mixture is hardly worth notice, being about four-fifths of 1 per cent. The amount in the diluted emulsion previously given is between 2 and 3 per cent.

QUASSIA EXTRACT.

This was made as follows: To 1 pound of quassia chips, 2 gallons of water were added and allowed to soak for four days, then boiled thoroughly for two hours, and filled up to the two gallons.

Applied pure, it killed the lice effectually where they were reached, but it will not spread. The importance of the wash spreading well can not be overestimated. This wash, like many others, seems to collect away from the lice, and only those under the drops are effectually destroyed. Diluted once it was still quite effective, but could not be used with any thoroughness. I do not consider this a practical remedy when used alone. The cost of quassia chips is 7 cents to 10 cents per pound.

QUASSIA AND SOAP NO. 1.

This was made after a formula given in Miss Ormerod's report, which is as follows: Quassia, 6 pounds; soap, 3 pounds; water, 100 gallons. The quassia was prepared as the extract previously mentioned, and the soap was my No. 1.

This wash killed quite effectively; it was about equal to best soap-suds. This result must be in part attributed to the quassia, as the least amount of soap per 100 gallons of water we found effective was 6 pounds, and this only under most favorable circumstances. The wash would not bear weakening. Quassia at 7 cents per pound and soap at 1 cent, the wash would be worth 45 cents per 100 gallons. At the village store I had to pay 10 cents per pound for quassia, which adds considerably to cost of the mixture as actually used.

QUASSIA AND SOAP NO. 2.

A mixture also made from Miss Ormerod's report. The formula was as follows: One pound soap, 1 pound of quassia, 22 gallons of water. In this the quassia helped the wash in effectiveness, as the suds without it was weaker than would kill. It was quite effective as a wash, equaling the best soaps. It would not stand further dilution.

The actual cost of the 22 gallons was about 11 cents, or 50 cents per hundred gallons. Quassia has long been known as a remedy, but from faulty methods of application and other points as noted under "Extracts" of same, its use has not been attended with best practical results. With soap mixtures it seems a valuable ingredient of the wash.

FISH-OIL AND LARD SOAPS.

A number of these were made, some of which were successful and others not. The object in view was an effective remedy at least possible cost.

Soap No. 1.

Formula: Loen Hirsh's Crystal potash lye, 1 pound; fish oil, 3 pints; soft water, 2 gallons. The lye was dissolved in the water, and when brought to a boil the oil was added. The batch should be cooked usually about two hours. It can be easily told when it is done by cooling a small portion in a cup. When done, if filled up to make the evaporation by boiling there will be about 25 pounds in the batch as given above.

This mixture made an excellent soap. When cold it could be cut and handled in cakes. Throughout the work it was the standard of comparison of all other washes.

The fish oil was an excellent article and cost 36 cents per gallon in New York City. The lye also was of good quality and cost a fraction over 9 cents per pound. This batch of 25 pounds thus cost 23 cents, or about 1 cent per pound. In all my work the washes were made entirely of soft water unless otherwise stated.

Standard suds of this and all other soaps was 1 pound to 4 gallons of water.

At this strength it did not injure the vines, spread well, and killed perfectly.

After standing several days this strength of suds became a thick, mucilaginous mass and could not be sprayed without further dilution.

The suds was used at different strengths up to 1 pound of soap to 16 gallons of water.

At this latter strength it spread fairly well, but was weak in action, and repeated tests showed that it was hardly safe for general use. However, if tests were re-sprayed before becoming perfectly dry, it invariably killed.

One pound of the soap to 8 gallons of water was found to be a uniformly safe and satisfactory wash, although after standing some time the suds would lose its efficacy. We became thoroughly convinced that soaps should be made and used fresh, and that suds should not be used after standing longer than three days. At one pound to 8 gallons, 100 gallons of this suds costs 12 cents, certainly a very reasonable price.

To the suds of this soap was added tobacco decoction No. 2 with good results. The mixture was as follows: 1 pound soap, 3 gallons tobacco water, 13 gallons of water, making 16 gallons of wash in all. This was very effective, but the cost of the wash was considerably increased over the plain soap. This mixture was suggested by my failure to make tobacco soaps which suited me and was tried just at the close of the work when there was not opportunity to test it out carefully.

We were convinced that soap washes are much improved by the addition of tobacco, yet such mixtures so far as made added to the expensiveness of the wash.

Soap No. 2.

This was an attempt to use crude potash but was an entire failure after repeated trials. It seemed impossible to make a good fish-oil soap with it.

Soap No. 3.

This was one of several resin soaps made for the work.

Formula as follows: One and one-fourth pounds lye, 1 quart fish oil, one-half pound resin, 2½ gallons of water.

The resin was melted in part of the lye and added boiling hot to the oil and the balance of the lye.

After cooking for two hours it appeared to saponify, but after standing a day or two became curdy. Many trials, varying the constituents, were made hoping to secure a good resin and fish-oil soap, but none proved entirely satisfactory. With lard I had no trouble.

Suds of this soap at standard strength kills slowly but effectually where all lice are thoroughly wetted. It was also used at 1 pound to 8, 12, and 16 gallons. It would kill fairly well even at weakest strength if very thoroughly applied, but would not be safe for general application weaker than 1 pound to 8 gallons of water, and at this it is not equal to No. 1.

This batch makes 28 to 30 pounds of soap and costs for material about 25 cents.

Soap No. 4.

This was an attempt to make a soda soap, but was entirely unsuccessful. It was made and remade from every formula in my possession but failed in each instance to saponify properly. The soda was the ordinary caustic soda, costing 5 cents per pound.

Soap No. 5.

This was another resin-oil soap made similar to No. 3, after the following formula: Two pounds lye, 1 pound resin, 3 pints fish oil, 13 quarts water. This was boiled for nearly three hours, when it appeared to saponify, but on standing for a day became curdy, although it was better than No. 3. Several attempts were made to recook these soaps, and by changing the proportion of ingredients, especially the water, to produce a soap of such consistency that it could be cut into cakes, but they were unsuccessful in every instance.

This batch should make 38 pounds of soap, if filled up to full measure after boiling, and costs 38 cents, a trifle more per pound than No. 3.

It was not as effective as No. 3. Standard strength killed very slowly. At weaker strength than 1 pound to 8 gallons it was of little use, and at this strength was not safe for general work.

After standing for some time the suds would scarcely kill at any strength. This soap was most thoroughly tested, and was in no sense a success, and it is very clear to me that resins in every case injure my soaps.

Soap No. 6.

This was lard soap made after the following formula: One pound lye, 4 pounds lard, 3 gallons water. This was cooked two hours and made a beautiful white soap

and firm, so it could be cut in cakes for handling. It made a good suds when dissolved, yet was not so smooth as the oil soaps and did not atomize as well.

The standard suds was quite effective, killing all but a few lice in course of fifteen minutes. It does not spread as well as oil soaps; in fact, the difference in quality of suds between oil and lard soaps is very noticeable. At 1 pound to 8 gallons it destroyed the lice fairly well, but above that only about 50 per cent. were killed.

This preparation would scarcely do for general work, even at 1 pound to 8 gallons. Mixtures of this soap which stood for several days became so ropy they could not be used at all, nor could they be diluted or be made to form a smooth suds. I do not consider this soap a useful article. Counting lard at 6 cents per pound, this soap cost 33 cents for 35 pounds.

Soap No. 7.

This was a lard-resin soap, made in the following manner: One pound lye, 5 pounds lard, ½ pound resin, 3 gallons water. Cooked as the other resin soaps. It made a good solid soap. This was most thoroughly used in the tests, but was a failure compared with the best results. Weaker than standard solution it was not at all effective, and at this strength was only a fair wash. It is scarcely equal to plain lard soap. In one test on a warm afternoon it did fairly well at 1 pound to 8 gallons. This batch makes about 36 pounds of soap and costs 44 cents.

Soap No. 8.

This was an oil-resin soap, made as follows: One and one-half pounds lye, 2 quarts oil, ½ pound resin, 3 gallons water. Cooked as other resin soaps. This was decidedly the best resin soap made so far as its appearance showed. But after two days it became slightly curdy. In the tests it was the least effective oil soap made. After repeated trials it was a failure at standard strength.

The resin soaps all made a good foamy suds, apparently strong, but not equal in caustic action to plain soaps. They were thus thoroughly tested because work with them elsewhere for Coccids had seemed to promise good results.

Soap No. 9.

This was a tobacco soap make in the following manner: One and one-half pounds lye, 3 pints fish-oil, 11 quarts water, 2 quarts tobacco decoction No. 2, boiled for two hours, did not saponify well; reboiled one and one-half hours and added 6 quarts water; saponified fairly well, was a black gummy mass, not solid enough to cut into cakes. All together this should make a batch of 50 pounds of soap at a cost of 40 cents. At standard strength this soap was hardly effective, and tests with weaker suds showed it to be of right value. It would not do for general work weaker than 1 pound to 4 gallons, and at that strength falls below the other soaps.

CONCLUSIONS.

Remedies applied in the middle of a warm day were always more effective than when applied early or late in the day or on a cold day.

Only liquid applications in the form of cheap washes are at all practical for this insect.

The application to be effective, *i. e.*, for best results, should be made in the form of a fine spray to the underside of the leaves, and if applied with considerable force the results are better.

The use of the patent or proprietary remedies which we have tested we do not consider practical.

Properly prepared kerosene emulsion and the plain fish-oil soaps are cheap, practical, safe remedies.

The addition of tobacco or quassia extracts to these can be made with advantage so far as quality of wash is concerned, but they will add to its expensiveness.

All extracts, decoctions, etc., which will not spread over the leaf, but collect in globules when sprayed, are not practical remedies, though they may kill the lice when brought in actual contact with them.

MACHINERY USED IN APPLYING INSECTICIDES.

In the small tests made especially to determine the effectiveness of different substances we used Woodason's blast atomizer. This is a hand-bellows with a cistern attached holding about one pint, and for use in a small way is very serviceable. It

has been previously illustrated and described in publications by this Division, and needs no special mention here. It makes a very fair spray, but for general field work would be entirely unserviceable.

Several small pumps were taken to the field for use in the work but proved to be of little or no value. Among these were the aquapult manufactured by W. & B. Douglas, Middletown, Conn., and a similar pump by W. J. Johnson, Newton, Mass.; also the Noël pump, fitted with the Vermorel modification of the Riley nozzle, both of which are manufactured in France. These pumps are good, serviceable implements for small work, but for the magnitude of the work here required were entirely inadequate.

The nozzles on these pumps should be mentioned. The first two were each equipped with a perforated rose nozzle, and the Douglas pump with a small colliding-jet nozzle. Both of these styles are very inferior for spraying purposes to other styles hereafter mentioned.

Of larger machines several styles were tried, involving practically no difference as to the principles of the machines, the points in view being capacity, ease of handling, and cheapness of construction.

The two points of prime importance in all spray machinery are a good pump and nozzle; other points are matters to be settled according to fancy of the user or requirements of the work.

A pump, to do good work, should be double-acting; and of the different styles those which have a single cylinder are decidedly to be preferred. All of the best makes, so far as we have seen them, are on essentially the same principle, being a small cylinder or piston within the larger or real cylinder of the pump. The action is by lifting on the upward stroke of the piston and by displacement on its downward stroke. The Douglas pump and all of the different aquapults are made on this principle.

The tendency of all makers, so far as our experience goes, is to too small capacity for heavy work like orchard and hop-yard spraying.

Few nozzles fill the requirements for such heavy work. The eddy-chamber system, of which the "Riley" is the best-known type, and the Climax nozzles come the nearest to perfection of anything we have used. The Riley nozzle, when properly made, is unsurpassed for making a perfect spray; but its adaptability to general work, in the quantity of spray and ease with which it can be used, is perhaps not so good as the Climax. This is particularly the case where the spray is to be projected upward above a level of three or four feet. For lower spraying the Riley nozzle has the advantage. The principle on which the Climax is made is the projecting of a stream of water against a wire screen. This is accomplished by means of a nipple made to fit hose couplings or nipples of such size as may be desired; on the outer end of this is screwed a brass tube varying in diameter and length according to size of nozzle.

The quantity of spray is regulated by the size of the orifice in the nipple, and on the outer end of the brass tube or chamber is fastened a screen of brass wire, varying in size of mesh to suit the size of the orifice in the nipple.

The oridinary field nozzles are made in four sizes, and are in outer dimensions 3 inches long by 1 inch in diameter. The liquid projecting through the nipple strikes the wire screen and is cut into perfect spray. This is an entirely new principle in the construction of spray nozzles and I believe from my tests it will be of considerable practical importance. This nozzle is the invention of Mr. A. H. Nixon, of Dayton, Ohio, and is manufactured and sold by a firm there.

The pumps used were also made by Mr. Nixon and were of two sizes; the small measured, stroke 3 inches, diameter of piston 1¼ inches, barrel 1¾ inches. The larger, stroke 6 inches, piston 1½ inches in diameter, barrel 2 inches in diameter.

These were used because they could be easily fitted to any box or barrel tank and came as near my idea of a practical pump as anything I had used.

On these pumps but two kinds of nozzles were used, the Cyclone and Climax. The size of orifice found most suitable for the Cyclone was one sixteenth of an inch, and of the Climax No. 2 of the regular sizes was used; the orifice in the nipple of this is one twenty-fifth of an inch.

The smaller pump was used entirely upon a hand-cart, intended for use as a lawn and garden engine. As made, it was only fitted with one discharge pipe. But upon experimenting in the field it was thought best to have two, and thus increase the capacity of the machine. This change was made, but the pump had not sufficient capacity to furnish two streams and work easily, hence we procured the larger pump before mentioned.

The nozzles are end discharge (Climax), hence the hose and canes used to support them are shorter than those shown on the larger machine.

There is some difficulty in spraying the lower leaves properly with an end nozzle, but when up to a height of 5 or 6 feet it is accomplished almost as readily as with a side-issue nozzle.

This difficulty was in part overcome by looping the hose downward at the outer end, so as to point the nozzle upward at an angle of about 45 degrees from the line of the supporting cane. This is easily done and very much facilitates spraying the lower leaves.

The larger pump was rigged to two different tanks, one a square box and the other a barrel supported on skids. This latter is shown as at work at Plate VII. This pump also had but one discharge pipe, but we had another fitted to it.

These tanks were made to illustrate cheaper apparatus, as the mounted hand-cart is costly, and the extra expense for wheels, etc., add nothing to its efficiency. The box tank holds 56 gallons of liquid, and the cost of material and labor for making was $8; the pump cost $9; two nozzles at $1, $2, and 40 feet of three-eighth-inch rubber tubing at 15 cents, $6, making the cost of a machine full rigged $25. In this estimate cost of canes to support the hose is not included but amounts to only a trifle. This machine also costs a considerable sum, but with proper care will last for years, and should be of great service in other ways than spraying hops.

Forty feet of hose is necessary for side-issue nozzles (20 feet to each discharge pipe). For end issue, 30 feet is plenty, which slightly reduces the cost of the machine. This pump was used for both side and end issue nozzles, and was a perfect success.

The feature of the side-issue nozzle is that the spray is delivered directly upward on the under side of lower leaves. It is necessary to use longer canes than for end issue, so that when reaching upper branches the angle of the supporting cane will not be so great but that the spray will be delivered nearly upward. There is an advantage in this that the spray is delivered farther away from the operator, and hence is not so unpleasant to him.

However, in practice, the farmers who assisted in the work very decidedly preferred short hose and end nozzles. The extra 5 feet of hose adds very much to the labor of handling the supporting canes. The proper length of cane is about 10 feet for short and 15 feet for long hose.

The barrel tank previously mentioned can be fitted up for at least $5 less than the box tank, and answers every purpose (see Plate VII). The bench to which the pump is fastened is made to fit the round of the barrel, and hooks down to the sides and end of the barrel as shown in the plate. The pump is bolted to this bench and then inserted through an opening in the barrel.

It is not a matter of any importance how the tank is supported on the boat, but the skid which we used is very convenient and can be easily made. It consists of 4 by 4 inch scantling, 2 feet 6 inches long. The bottom pieces are placed 18 inches apart and the top pieces 13 inches apart, and bolts put through each corner. The top pieces should be rounded on the inner surfaces to meet the rounding sides of the barrel. I will add here, concerning the pumps, that a flexible tube (hose) is fitted to the lower end of the pump cylinder of sufficient length to reach the bottom of whatever tank used. This supply pipe should always be covered with a strainer.

The method of drawing the tanks through the fields on a flat-boat is cheap and convenient; other methods could, however, easily be devised. A barrel mounted on runners can be easily drawn by one horse anywhere over cultivated ground, and is a very conveniently rigged apparatus.

All tanks should be provided with a strainer, through which the liquid is poured. This is of considerable importance, and will help very much to prevent clogging of the nozzles.

A matter of importance in equipping spray machines is the size and style of hose to be used. Ordinarily, spray pumps are fitted up with one-half to three-quarter inch heavy hose. To handle these on a cane pole of any length requires more strength than any other part of the work, and they are entirely useless and unnecessary. A good cloth insertion three-eighths or one-quarter inch rubber tubing will answer every purpose and decrease the weight to be handled about 50 per cent. The one-quarter-inch tubing will furnish a stream to the largest nozzle necessary for any ordinary work. Such hose can be bought, of fair quality, at 12 cents per foot for the larger and 9 cents for the smaller size.

These sizes are not kept in stock by local dealers, especially in villages, but can be ordered of any large dealer.

FIELD TRIALS OF SPRAY MACHINES.

Several field trials with machines were made to practically demonstrate their workings. The trials were witnessed by farmers and others interested, though no attempt was made to make them of a particularly public nature. Messrs. Martin and Springer Goes assisted in the trials.

On August 3 the mounted hand-cart was used at Mr. Goes's yard. We were able

to spray at the rate of 2 acres per day, two persons handling the machine. It was very evident from this trial that hauling the machine by hand for any length of time was quite out of the question, and in all future trials whatever tank we used was drawn on a flat-boat as shown in Plate VII. Also the idea of having two discharge pipes, thus doubling the capacity of the machine with the addition of but one man, took shape at this test.

On August 11 the second trial was made at Dr. Norman Getman's yard, about 2½ miles from town, along the shore of Canadarago Lake. In the meantime the pump had been fitted with two discharge pipes. One man worked the pump and drove the horse without difficulty. We used both side and end issue nozzles, but the side issue (Cyclones) were not practical on short hose because of the almost perpendicular position of the poles when reaching the top branches. For the lower parts of vines they worked well; they did not, however, pass the liquid in sufficient quantity for rapid work. The end-issue nozzles worked very satisfactorily.

The trial was not as satisfactory as I had hoped, from two causes: (1) The pump had not sufficient capacity to supply the two streams perfectly; (2) from a defect in fitting the hose to the pump one of the pipes leaked so as to greatly hinder the test. The work was in the main satisfactory to those witnessing it, all being satisfied that spraying by hand was practical.

Dr. Getman timed the work, and the test showed a rate of between 3 and 4 acres per day.

From this experience we decided to rig up a pump that would supply two streams with ease, also to show how to arrange a cheaper apparatus. In carrying out this idea the large pump was procured, and the box and barrel tank fitted up as elsewhere described.

Several tests with these and also the mounted machines were made on August 18 to 23. Side and end issue nozzles were used and tested in every possible manner to the satisfaction of myself and several gentlemen present. During these tests the orifice in the side-issue (Cyclone) nozzles was three times enlarged, until they were made one-sixteenth of an inch in diameter at which size they worked very well.

Considering the different tests made as to rapidity of spraying we were able to reach a speed of 4 acres per day under the most favorable circumstances, but generally averaged about 3 acres or a little better with the Cyclone nozzles. With the end-issue (Climax) nozzles we were usually able to make a little better speed and to more thoroughly drench the vines, the amount of spray passing these nozzles being greater than the side-issue nozzles, though the opening is of less size, being but one twenty-fifth of an inch in diameter. This is probably explained by the fact of the liquid passing these nozzles in a straight line, while in the Cyclones it is arrested in the eddy chamber and issues from the side.

The spray from the Climax nozzle also reaches to a farther distance than from the Cyclone.

The best rate of speed made with the end-issue nozzles was 4 acres per day or a little better. However, in all these tests the measurement was for a full stand of vines, which is often not the case, and the missing hills would accelerate the speed of spraying. Also the tests were made when the vines were nearly or quite full grown, when in practice spraying would doubtless be done a month earlier, thus lessening very much the surface of vine to be covered and making the probabilities of reaching the under side of all the leaves much greater.

The general expression of those witnessing the tests was in favor of the end-discharge nozzles, but taking into consideration the fact that much of the spraying would be done before the vines had attained such a top growth as when this work was done, the side-issue nozzle might prove equally serviceable. Certainly, for delivering spray into the top of the vines, the end nozzle is best.

So far as the gentlemen witnessing the different tests expressed themselves, they were decidedly of the opinion that the spray apparatus was a success, and that a maximum speed of at least 4 acres per day could be easily acquired with a little practice.

LOCAL EFFORTS MADE TO DESTROY THE HOP-LOUSE.

Comments concerning the attempts made by local growers to destroy the lice were occasionally heard during my work, but I was able in but one case to get the facts as to the means used with some probable degree of certainty. This was the work done by Mr. T. F. Pier, of Springfield Centre, Herkimer County. Mr. Pier is an old gentleman of large experience in hop-growing, having grown and dealt extensively in them all his life.

Last season (1886), when he saw that his hops were going to be utterly ruined if something was not done, he went to work and sprayed them in the following manner: As near as he could recollect he put 25 pounds of tobacco waste in a large

boiler and cooked it thoroughly, then put the decoction thus made into 100 gallons of water. This was sprayed onto the hops by means of an old garden engine, drawn on a boat by horse. One man drove, another worked the pump, and a third held the nozzle. There was no spray attachment used; the nozzle threw a three-eighths of an inch solid stream and the hills were thoroughly wet down. Much of the liquid was thus wasted. Two applications were made early in July, about the 10th. The second application almost entirely destroyed the lice so that vines made some growth, but the injury was already so great that there was no crop. Mr. Pier thinks his hops much better this year from the effects of treatment, as they were able to complete their growth and thus leave the roots in better shape for this year. I can testify that his crop this year was heavy and of very fine quality. About 200 pounds of tobacco waste was used and 15 acres of yard treated.

We heard of another instance where a grower sprayed his hops with strong tobacco decoction and saved them, but the odor of tobacco was so strong on the burs they were almost worthless. We were not able to personally inquire into this case. There was a sort of common expression among growers that sowing buckwheat was in some measure a protection, but last season, when there was abundant opportunity to test it, not a yard was saved by this means that we could hear of, and from our inquiry came to the conclusion that it would not be of much efficacy; and as a practice it certainly does ruin the yard.

SILK-CULTURE—REPORT OF THE YEAR'S OPERATIONS.

MADE TO THE ENTOMOLOGIST.

By PHILIP WALKER, *Agent in charge.*

The correspondence of the Silk Section of the Division has increased very materially during the past year, 6,973 letters having been received during 1888. The experimental silk filature has, as has already been explained (page 17 of the Commissioner's report to the President), been virtually at a standstill since the 7th of February, when the old model Serrell automatic machines were removed to make room for those of more recent construction which were mentioned in the last annual report. These machines, however, did not give satisfaction, and I have been at work ever since in endeavoring to perfect them so as to produce a really automatic silk-reel. I have at present every reason to believe that I have accomplished the desired result.

As the filature is situated in the museum of the Department it has been thought best to keep a hand-reel in operation for the benefit of visitors. On that reel I have consumed 168 kilograms of cocoons and produced 38 kilograms of silk. No attempt has been made to keep this work within economic limits, as will be seen by the result.

In compliance with your instructions I operated two machines of the old automatic type at the Cincinnati Exhibition during the past summer. They attracted a great deal of attention and did good service in educating the people. We also exhibited samples of cocoons and silk and various models and charts instructive to silk-raisers.

The section will also be represented at Paris by samples of American cocoons and silk produced at our filature.

DISTRIBUTION OF SILK-WORM EGGS.

Last year we distributed 150 ounces of the following varieties:

Italian.—Pucci (Umbrian race).
Tranquilli (Ascoli race).
Mercolini (Marches race).

French.—Deydier (Cevennes race).
Raibaud l'Ange (Lower Alps race).
Goulier & Requier (Var race).

They were distributed to the following States:

States and Territories.	Lots.	Ounces.	States and Territories.	Lots.	Ounces.
Alabama	38	8	Mississippi	24	4⅝
Arkansas	27	4⅝	Missouri	56	9⅛
Colorado	1	⅛	Nebraska	31	3⅝
Connecticut	2	⅜	New Hampshire	1	⅛
Dakota	2	¼	New Jersey	7	1¼
Delaware	1	⅛	New Mexico	1	¼
District of Columbia	1	¼	New York	10	1¼
Florida	72	18	North Carolina	27	7⅜
Georgia	50	11⅞	Ohio	100	15⅞
Illinois	61	8⅞	Pennsylvania	29	3⅝
Indiana	54	8⅞	South Carolina	32	8¼
Indian Territory	2	⅜	Tennessee	36	7⅝
Iowa	3	⅜	Texas	83	21¼
Kansas	155	28⅛	Utah	1	¼
Kentucky	29	5¼	Virginia	28	5
Louisiana	27	6¾	Washington Territory	1	⅛
Maryland	13	2⅝	West Virginia	9	1¼
Massachusetts	5	1⅛	Wisconsin	2	¼
Minnesota	4	⅝			

For the first time in the history of the office the demands far exceeded the supply of eggs, and after having distributed 1,037 lots of eggs, as shown above, varying in quantity from one-eighth ounce to one ounce (25 grams) there still remained 698 unfilled applications. The season begins in Florida in February and in Wisconsin in May, so that the silk-raisers of the South had in general their wants supplied, while those of the North, applying later, we were forced to deny or to supply with one-eighth-ounce lots. This exhausting of our supply, the burden of which fell upon the States raising the largest crops, had a very material effect on the cocoon product, as will be seen later on.

In order that the same difficulty should not again arise, we have this year purchased 500 ounces of eggs, as follows:

French.—Deydier (Cevennes race).

Italian.—Mercolini (Marches race), Pucci (Umbrian, two races).

These 500 ounces of 30 grams have been divided into 2,495 boxes of one-quarter ounce, the smallest quantity which will this year be given to one person. Already (February 1) there are more than 900 boxes promised to 700 applicants.

PRODUCTION OF COCOONS IN THE UNITED STATES IN 1888.

The production of cocoons in the United States has probably decreased during the last year. Of the crop of 1887, as stated in my last report, 6,174 pounds were purchased as follows:

	Pounds.
Washington	2,213
Philadelphia	2,196
Peabody, Kans	1,765
Total purchases east of the Rocky Mountains	6,174

The crop of 1888 has been purchased as follows:

	Pounds.
Washington	2,038
Philadelphia	1,193
Peabody, Kans	682
Total purchases east of the Rocky Mountains	3,913

From this it will be seen that the purchases of this filature fall below those of last year by nearly 200 pounds; those of Philadelphia show a decrease of 1,000 pounds, and those of Peabody a diminution of 1,083 pounds, making the total purchases of the crop of 1888 2,261 pounds less than the crop of 1887. I have been able to obtain no returns from California.

On the face of these returns it would seem that the interest in silk-culture in the United States had decreased very materially between 1887 and 1888. I do not, however, think that this is a fact. I ascribe the decrease more especially to the fact that we were not able last year, as has already been stated, to fill the application for silk-worm eggs. Of the crop of 1887, we received two hundred and seventy-nine lots; of the crop of 1888, we received four hundred lots. In 1887, eighty-one samples were sent us, which were not followed by lots, our bids not being accepted. In 1888 ninety-eight persons sent samples without sending lots. From this it will be seen that we, in 1887, communicated with three hundred and sixty correspondents in regard to the purchase of cocoons, while in 1888 that number rose to four hundred and ninety-eight.

On the other hand, it will be observed from the list which follows that in 1887 sixty-four persons received more than $10 for their season's work, and that nine persons received more than $40, while in 1888 only forty-eight persons received more than $10, and nobody was paid as much as $40. In 1887 the average price paid for each lot of cocoons was $7.81; in 1888, it fell to $4.53.

I attach hereto also a list of purchases from each State and Territory by the different purchasing filatures. It will enable one to understand where the principal interest in silk-culture is shown:

List of persons receiving more than $10 for their cocoons.

CROP OF 1887.

Name.	Town.	County.	State.	Amount paid.
Mrs. L. R. Fuller	Clarkesville	Habersham	Georgia	$10.50
Martin Mayer	Conant	Perry	Illinois	10.50
Mary W. Leigh	Clarksville	Mecklenburg	Virginia	10.50
S. McSmith	Carthage	Jasper	Missouri	10.62
Baab & Leibroch	Nashville	Washington	Illinois	11.02
Mrs. D. D. Gleason	Rosedale	Jersey	...do	11.02
Eva Alden	Alaska	Kent	Michigan	11.50
S. M. Wilson	Buffalo	Wilson	Kansas	11.55
Gustav Hardy	Maxville	Perry	Ohio	11.55
Mrs. Mollie Miller	Baltimore	Fairfield	...do	12.07
Fred W. Scott	Elmwood	Cass	Nebraska	12.10
James Maiz	Northampton	Hampshire	Massachusetts	12.60
George Nixon	Jefferson City	Cole	Missouri	12.65
Sallie Harris	Woodburn	Macoupin	Illinois	12.65
Mrs. H. C. Roberts	Spring Arbor	Jackson	Michigan	12.93
Martha Delaney	Carbondale	Jackson	Illinois	12.93
Lena Beeker	Herborn	Shelby	...do	13.12
Henry L. Briggs	Schuyler	Colfax	Nebraska	13.75
J. B. Mercer	New Supply	Brunswick	North Carolina	13.80
Minnie Partridge	Paris	Edgar	Illinois	13.91
Mrs. J. M. Fakes	Carbondale	Jackson	...do	13.94
Mrs. J. S. Douglas	Zanesville	Muskingum	Ohio	14.17
Miss T. M. Eberhardt	Bronson	Branch	Michigan	14.30
Kate F. Newkirk	Harrell's Store	Sampson	North Carolina	14.70
Mrs. E. R. Miller	Fair View	Concordia	Louisiana	15.52
Mrs. W. J. Nelthorpe	Burlington	Calhoun	Michigan	15.95
Jessie Franklin	Saundersville	Sumner	Tennessee	16.67
Mrs. J. R. Seymour	Newark	Licking	Ohio	17.05
Miss Libbie Paull	Gahanna	Franklin	...do	17.05
H. W. Seavey	Harrell's Store	Sampson	North Carolina	17.32
Mrs. Adelle Walton	Hollow	Saint Louis	Missouri	18.11
A. G. and V. E. Hinckley	Galesburgh	Knox	Illinois	18.15

List of persons receiving more than $10 *for their cocoons*—Continued.

CROP OF 1887—Continued.

Name.	Town.	County.	State.	Amount paid.
Miss Louisa Benoit	Woodburn	Macoupin	Illinois	$18.40
Mrs. S. C. Allen	David City	Butler	Nebraska	18.62
Mrs. Richard Willis	Towson	Baltimore	Maryland	18.70
Amos K. Glen	Blair	Randolph	Illinois	19.55
Lucia Williams	Brushy Creek	Anderson	South Carolina	20.25
J. S. Ferguson	Carterville	Jasper	Missouri	20.70
Mrs. O. G. Thompson	Goldsborough	Wayne	North Carolina	21.27
George Langman	Corwin	Preble	Ohio	22.00
Kate Early	Fair Haven	...do	...do	22.00
Mrs. Adellio Tilton	Canal Fulton	Stark	...do	22.57
Mrs. F. W. Curtis	Arcola	Douglas	Illinois	23.00
Henry L. Judd	Marine	Madison	...do	23.00
Almeda Adams	Montserrat	Johnson	Missouri	23.62
H. Dutsch	Covington	Saint Tammany	Louisiana	26.45
Jennie Rosamond	Brushy Creek	Anderson	South Carolina	27.90
Mary E. Kinny	Mokena	Will	Illinois	28.75
Mrs. E. A. Gibbs	Palatina	Cook	...do	31.62
Jennie Rosamond	Brushy Creek	Anderson	South Carolina	32.77
M. T. Jones	Goldsborough	Wayne	North Carolina	35.70
Mrs. Lucy M. Fox	Spring Garden	Volusia	Florida	38.00
Mattie C. Young	Woodburn	Macoupin	Illinois	43.98
R. M. Newman	Gordonsville	Orange	Virginia	46.40
F. A. Williams	Tamaroa	Perry	Illinois	48.60
Maggie Brayshaw	Du Quoin	...do	...do	51.75
E. M. Palmer	Glendale	Pope	...do	51.75
J. B. Dickey	Newton	Harvey	Kansas	64.54
J. C. Muller	New Orleans	Orleans	Louisiana	64.62
Mrs. F. J. Adams	Montserrat	Johnson	Missouri	77.91
Henry L. Judd	Marine	Madison	Illinois	98.90

Total number of lots 279
Lots costing more than $10 64

CROP OF 1888.

Name.	Town.	County.	State.	Amount paid.
Mrs. H. E. Preston	Grant Park	Kankakee	Illinois	$10.00
Mrs. Alfred Fahnestock	Chambersburgh	Franklin	Pennsylvania	10.20
Miss Eva Alden	Alaska	Kent	Michigan	10.23
John M. Hanssen	Grand Island	Hall	Nebraska	10.35
Miss L. Addie Gaston	Duncans	Spartanburgh	South Carolina	10.72
Miss Clara A. Cooper	Henderson	Knox	Illinois	10.75
Miss Clara Slough	Daytona	Volusia	Florida	10.76
Martin Moss	Goodwin's Corner	Union	Indiana	10.80
Mrs. A. J. Mercer	New Supply	Brunswick	North Carolina	11.00
Justus Baab	Nashville	Washington	Illinois	11.00
Mrs. Sarah B. Johnson	Penfield	Champaign	...do	11.00
Mrs. R. S. Fairbanks	Lindenville	Ashtabula	Ohio	11.02
David Jones	Wyoming	Stark	Illinois	11.25
James L. Webb	Anderson	Madison	Indiana	11.55
Mrs. I. D. Graham	Lane	De Witt	Illinois	12.00
Mrs. Fred A. Reynolds	Buda	Bureau	...do	12.20
Mrs. J. S. Ramsey	Oconee Mills	Hall	Georgia	12.25
Martin Mayer	Conant	Perry	Illinois	12.68
Fred Josse	Piqua	Miami	Ohio	12.80
Miss Minnie Jager	Neosho	Newton	Missouri	12.93
Willard Thing	Du Quoin	Perry	Illinois	12.96
D. G. Friesen	Jansen	Jefferson	Nebraska	13.20
Nettie Painter	Rockingham	Rockingham	Virginia	13.81
Mrs. Carrie Price	Kosse	Limestone	Texas	14.06
Mrs. Kate C. Dutton	Toronto	Woodson	Kansas	14.25
A. Jane Ball	Cleveland	Bradley	Tennessee	14.85
Miss Maggie Brayshaw	Du Quoin	Perry	Illinois	15.50
Mrs. H. H. Jeter	Arcola	Douglas	...do	15.75
Mrs. George J. Ford	Carlton Station	Orleans	New York	19.12
Miss Clara A. Cooper	Henderson	Knox	Illinois	19.60
Mrs. D. L. Gibson	Plymouth	Marshall	Indiana	20.18
Beulah Wallace	Bloom	Cook	Illinois	20.30
Miss Jennie Rosamond	Brushy Creek	Anderson	South Carolina	20.35
Miss Hannah Seavey	Harrell's Store	Sampson	North Carolina	20.47
John Rickenbacher	Gahanna	Franklin	Ohio	22.00
Mrs. M. W. Dare	Newark	Knox	Missouri	22.50

List of persons receiving more than $10 *for their cocoons*—Continued.

Name.	Town.	County.	State.	Amount paid.
Miss Anna Kohler	Chilo	Clermont	Ohio	$22.50
Mrs. Sarah L. Jones	Piqua	Miami	...do	23.10
Dora Longman	Corwin	Preble	...do	25.20
Mrs. C. M. Wilson	Hebron	Porter	Indiana	25.72
Mrs. Sarah Lackey	New Bellsville	Brown	...do	25.85
J. Gottlieb Schatz	Amboy	Blue Earth	Minnesota	26.25
Miss Amanda Shelton	Arcola	Douglas	Illinois	26.50
Mrs. Fannie Forbes	Concordia	Cloud	Kansas	29.32
Mrs. F. W. Curtis	Arcola	Douglas	Illinois	29.70
Mrs. L. Vial	Cave City	Barren	Kentucky	32.33
Mrs. E. Mackey	Pleasonton	Linn	Kansas	34.12
Fred Josse	Piqua	Miami	Ohio	38.85

Total number of lots 400
Lots costing $10 or more 48

Product of cocoons for the crop of 1888, *as shown by the purchases.*

States and Territories.	Washington.	Philadelphia.	States and Territories.	Washington.	Philadelphia.
	Lb. oz.	*Lb. oz.*		*Lb. oz.*	*Lb. oz.*
Alabama	32 4	5 7	Missouri	137 9	162 11
Arizona			Montana		
Arkansas	15 14	3 12	Nebraska	46 14	10 11
California			Nevada		
Colorado			New Hampshire		
Connecticut	1 8	2 13	New Jersey		3 3
Dakota			New Mexico		
Delaware		6 1	New York	22 8	2 14
District of Columbia	3 4		North Carolina	54 8	12 10
Florida	71 12	72 5	Ohio	304 4	375 11½
Georgia	31 3	1 0	Oregon		
Idaho			Pennsylvania	45 0	96 7½
Illinois	440 2	140 0	Rhode Island		
Indiana	178 10	70 13	South Carolina	78 2	1 3
Indian Territory	2		Tennessee	34 15	
Iowa	14 4	12 15	Texas	66 7	38 0
Kansas*	201 10	40 5	Utah	2 4	
Kentucky	62 12	10 4	Vermont		
Louisiana	36 10		Virginia	62 3	6 3
Maine			Washington		
Maryland	6 3	19 6	West Virginia	12	
Massachusetts	10 8	5 2	Wisconsin	8	
Michigan	85 2	93 3	Wyoming		
Minnesota	37 14				
Mississippi	2 8		Total	2,088 0	1,193 0

* In addition to this, Kansas produced 682 pounds, purchased by the station at Peabody.

CO-OPERATING ORGANIZATIONS.

During the past year the work of the Kansas State Silk Commission has been continued at Peabody, Kans. Unfortunately, however, too great a proportion of its biennial fund was expended during the first year, and the commission has been somewhat cramped financially of late. It has, however, made material purchases of cocoons, as shown elsewhere, and has been generally of great assistance to sericulture in Kansas by giving advice and encouragement to silk-raisers in that State.

The Women's Silk Culture Association of the United States at Philadelphia has been working under an appropriation of $5,000 for the last fiscal year, and this appropriation has been repeated for the year ending June 30, 1889. The association submitted a report to Congress, through this Department, August 17, 1888, showing its operations for the fiscal year then just terminated, and this report

was published (H. R. Mis. Doc. No. 103, 50th Cong., 2d sess.). Since the publication of that report its president has forwarded us a summary of their purchases of cocoons, which will be found on another page. She also informs me that they have distributed during the summer 5,338 mulberry trees.

The Ladies' Silk Culture Society of California was also the recipient of an appropriation of $5,000 during the last fiscal year, which was reduced to $2,500 for the present year. The principal endeavors during the last year were to get their mulberry orchard at Piedmont into good condition preparatory to more extensive operations. A report of their work for that period has already been submitted to Congress and published (H. R. Mis. Doc. No. 543, 50th Cong., 1st sess.).

Congress also made an appropriation for the present fiscal year to enable Mr. Joseph Neumann, of California, to experiment with what was claimed to be a newly discovered native silk-worm. His report, which was recently submitted to Congress and printed (Sen. Mis. Doc. No. 29, 50th Cong., 2d sess.), shows that he had rediscovered the *Attacus cecropia*, a worm which has been well known to naturalists in this country for a long period of time, and whose habits have long since been thoroughly studied.

A new organization has appeared at Baltimore, Md., entitled the Southern Land and Silk Association. This association has purchased land in the neighborhood of Annapolis and has colonized it with about thirty families. The coming season will be their first, and therefore there is no report to be submitted upon their work.

APPARATUS FOR WASHING SILK-WORM EGGS.

In the production of silk-worm eggs there is always a certain quantity of light and worthless eggs as well as much loose dirt which should be removed before the grain is put upon the market. This may be done by relying on the fact that the good eggs will generally sink and the bad ones and the dirt rise to the surface in a vessel of water. At our request we were furnished with designs of an excellent apparatus, embodying these principles, by Signor G. B. Debernardi, editor of the journal *Industria Serica*, of Turin. The apparatus was invented, we believe, by one Broglio, of Bologna.

It consists, as we have had it constructed, of five tin reservoirs, B, C, D, E, and F, Plate V, fig. 1, inside of each of which there is a movable lining with a perforated bottom. The eggs are placed in the reservoir B and a stream of water, sufficiently strong to keep the eggs in motion, is admitted through the inlet pipe A. The light eggs, as well as some of the good ones, rise to the surface and overflow into the pan C, thence to D and E, and finally to F, from which latter reservoir the water passes through the outlet pipe G. In each overflowing some of the good eggs will go to the bottom while the light ones will continue on the surface and be finally collected in the pan F. It is found that one or two repetitions of this operation will remove all the light or poorly fecundated eggs.

SCIENTIFIC TESTING OF COCOONS.

In the scientific determination of the value of the cocoons of the *Bombyx mori*, many more features are studied than is thought necessary in commercial dealings. The silk-reeler, beyond the observa-

tion which he can give by sight and touch, and the rough estimation of doubles and satiny cocoons, never puts fresh cocoons to any further or more searching test. In the purchase of dry cocoons, which are usually bought in larger lots than fresh ones, he takes the additional precaution of having one or two kilograms reeled by his more expert operatives and noting the rendition and the quality of the silk produced.

The scientist, however, more especially in the comparison of races, pushes his researches further. At the silk laboratory at this Department, the following observations are made upon a sample of twenty cocoons so selected as to represent the lot which is the object of study:

The dimensions of all the cocoons are determined; that is to say, the length and the diameters at one end and at the constricted center.

Each cocoon is weighed in milligrams. Weighing to one-tenth of a milligram is so delicate an operation that it is not thought worth while to pass the time necessary therefor, as the results would be of but little if any greater value.

The cocoons are then divided into three lots, consisting of ten cocoons for reeling, six cocoons for boiling off, and four cocoons for volumetric determinations.

The reeling is performed upon a special machine which is a modification of my own design of the one used in the Lyons laboratory. It will be described further on. The single cocoon is here taken, and the end having been obtained with the production of as little frisons as possible, is unwound in skeins of one hundred meters each. Between each of these skeins a sample five meters long is taken off on a card for miscroscopical measurements and serimetric tests of its tenacity and elasticity. The total length of the filament of each cocoon is thus found, together with its diameter, strength, and elasticity at each one hundred meters. The weights are also ascertained of the frisons, reeled filament, and telette.*

In the boiling off the six cocoons are first dried in the conditioning oven until all the water is expelled. The correction thus noted is applied in obtaining the net weight of all of the twenty cocoons of the sample. They are then cut open and the chrysalides and castings removed and weighed. The silken pods are also weighed, all six together. They are then thoroughly boiled in distilled water to remove the wax, and then in a saturated solution of white castile soap to dissolve the gluten (*grès*). They are dried and weighed after each operation, and we have thus the weight of the chrysalides and castings, and of the wax, gluten, and fibrine of the silken pod.

The remaining four cocoons are measured in the Blanc volumeter, to be further described.

For the greater facilitation of the many operations entailed in the boiling off I have devised a small multiple hook, shown in Plate XI, fig. 4. It consists of a small German-silver wire, at the top of which is an eye and at the bottom a small plate, from which radiate six hooks. The six cocoons are first well slashed with a section-cutting knife, so that the chrysalides and castings may be easily removed at the proper stage. They are then firmly affixed, one to each of the radiating hooks, and there they remain during the whole series of determinations, the boiling kettles and drying oven being so arranged

*Telette. That portion of the cocoon and chrysalis remaining after all the silk possible has been unwound.

that they may be conveniently suspended in them. The handling of the cocoons is thus entirely avoided, as the wires are always grasped by a special form of pincers and moved from one piece of apparatus to another.

The balance used is one made especially for me by Troemner, of Philadelphia, and so adjusted as to weigh to 1 millimeter on the divided beam. This insures rapid and sufficiently accurate work.

APPARATUS FOR MAKING THE ABOVE TESTS.

Indicator Oven for drying Cocoons.

It has been stated that in the boiling off of cocoons it is necessary to carefully dry the sample under inspection at each stage of the operation. The necessity of this will be understood when it is remembered that, besides the free water adhering to the silk upon its removal from the boiling kettles, the fiber itself will absorb, of moisture, as much as 24 per cent. of its dry weight. It is therefore not possible to know, without thus reducing to absolute dryness, what proportion is water and what silk. In an atmosphere of ordinary dryness the silk will contain about 10 per cent. of water, and this amount has been agreed upon as a standard. In what is called the "conditioning" of raw silk all the water is dried off in a "conditioning oven" and the silk is weighed while still in the oven. To the weight thus determined is added 11 per cent.,* and the weight thus obtained is called the "conditioned weight" of the silk.

In handling the many small samples which pass through our laboratory much time is lost in drying the cocoons. On the other hand, the operation of weighing may be performed with rapidity. The greater portion of the water is first driven off in a steam bath and the cocoons are then transferred to an oven, which for convenience I call the "indicator," inasmuch as the balances used are not of sufficient delicacy to show the final weight, but only indicate the time when about all the water has been expelled.

This indicator consists of a long pan with a triple wall, as shown in Pl. V, fig. 2. It is surmounted with six small balances, each having a saddle on one arm of the beam. To the other arm is suspended a pan into which, the saddle being at zero, is poured a sufficient quantity of sand to counterbalance the weight of the wet cocoons. As the water is driven off the cocoons become lighter, and the saddle is slipped along the beam to counteract the loss. When this reduction in weight ceases the cocoons are transferred to the Troemner balance mentioned above, and accurately weighed.

Caliper for measuring Cocoons.

The necessity for some quick method of measuring cocoons led me to devise the apparatus shown in Plate VI, fig. 1. It consists of a pointer, D, to which is attached a finger, B, which, in a position of repose, rests upon another finger, A, attached to the base of the apparatus. At the end of the pointer is a divided circle, E, whose radius is four times the distance from A to the center of movement. The axis upon which the pointer swings is terminated by a milled head, C, by which

* Calling the dry weight 100 per cent., we thus have 100 per cent. plus 11 per cent., which equals 111 per cent. Now, the 11 per cent. is essentially 10 per cent. of 111, and the silk so reduced thus contains 10 per cent. of water as stated above.—P. W.

the pointer can be maneuvered. The cocoon to be measured is placed between the fingers A and B and the dimension desired is at once indicated on the scale. This system is more rapid than those which employ Vernier or other calipers and is sufficiently accurate for all practical purposes. While the scale indicates but millimeters it is possible to approximate to quarters of millimeters, as the divisions are at least 5 millimeters long.

The Blanc Cocoon Volumeter.

Although we have determined the principal dimensions of our sample cocoons we wish to obtain still further information by studying their volumes. The great diversity of form existing among cocoons makes it impossible to calculate the volumes from the length and diameter, and we are therefore forced to have recourse to direct experiment. For this purpose we employ a volumeter designed by Mr. L. Blanc, of Lyons, and constructed for us by Eimer & Amend, of New York, after designs published in the third annual report of the Lyons Silk Laboratory. It is shown at Plate VI, fig. 2. It is based upon the fact that any body completely submerged displaces a volume of liquid equal to its own volume. Mr. Blanc's own account of the apparatus is excellent and is reproduced here:

The volumeter is composed of a reservoir, B, whose dimensions are such that the largest cocoons can be easily introduced into it. This bottle is closed by a stopper, which is surmounted by a tube, A. The stopper sets into the mouth of the bottle with a ground joint which is carefully adjusted. The tube A is divided into tenths of a cubic centimeter, and the zero of the graduation (which reaches 10 cubic centimeters) is placed at its lower end.

The exact capacity of this apparatus to the zero point being known it is easy to determine the volume of any cocoon which is placed in it. It is only necessary, after the cocoon has been inserted, to empty into the upper end of the tube, which is slightly enlarged, a volume of liquid such as, were the instrument empty, would rise to the zero of the graduated tube. This liquid, instead of stopping at zero, mounts higher in the tube by a quantity equal to that of the volume of the cocoon. A simple reading of the scale will then give the quantity of water displaced and consequently the volume of the cocoon placed in the reservoir.

To arrive at sufficiently accurate results we must take several precautions. We begin by preparing the cocoon. After having taken off with the fingers all the floss possible, we place the cocoon on the end of a needle point and pass it lightly through the flame of an alcohol lamp, in order to remove the filaments which might adhere to it and retain air bubbles. Then, to prevent the action of water, which would otherwise penetrate the pod and soften and deform it, and thus interfere with the results of the experiment, we plunge it into a varnish composed by dissolving some flake shellac in alcohol. After leaving it for a minute or two in this liquid we take it out and allow it to drip and dry. It is then ready to be measured.

The apparatus is then carefully dried and the edge of the stopper greased with vaseline, so that the closing may be hermetic. The cocoon is then placed in the reservoir and the stopper is allowed to fall into place by its own weight only.

This done, we fill with water a pipette which holds the same quantity of liquid as does the volumeter up to the zero point of the tube. We then empty this quantity of liquid into the apparatus through the upper end of the tube, performing the operation slowly, so as to prevent the formation of bubbles. The water will fill the apparatus and raise the cocoon on its surface until it reaches the upper part of the bottle.

We then ascertain whether there is any air left in the apparatus, and if there is, we cause it to escape by stirring the cocoon with a small greased copper or iron rod, which we introduce by the tube. When the liquid is at rest we make the reading on the tube, and we thus have the volume of the cocoon.

It is well to make several measurements with the same cocoon or with two cocoons of the same kind and take their mean.

As the tube C is graduated to tenths of a cubic centimeter it must not be supposed that the approximation attained by this instrument is very great. We can, in fact, in filling the pipette, make an error of reading which would be equivalent to about a fifth of a cubic centimeter. There is also another cause of error, of little importance when the cocoons are large, but much greater when the cocoons are small, and which it will then be well to avoid. This is the moisture on the pipette.

In fact, when we empty the pipette into the apparatus a certain quantity of water always adheres to its sides and indicates reduced volume for the cocoon. If we wish to avoid this cause of error we should determine, by several preliminary trials made with an exact balance, the quantity of water which thus remains on the sides of the pipette.

Finally, two other difficulties may present themselves. We may have cocoons whose volume surpasses 10 cubic centimeters. In such a case we should reduce the quantity of water placed in the apparatus by 10 cubic centimeters and add that figure to the result obtained.

We may also wish to evaluate the volume of a loosely woven cocoon, such as that of the *Cricula trifenestrata*. We must then close all the openings by which the cocoon is pierced. To do this we should, after having passed it through the flame, spread over the surface by the aid of a brush a thin layer of semi-fluid collodion. We thus envelope it with a membrane which becomes very thin after the evaporation of the ether. It may then be submerged like an ordinary cocoon.

We see that the instrument which we have just described is not one of absolute precision, but the errors which will be committed in using it are inferior to the differences which exist between many cocoons of the same kind, of which the volume appears to be the same.

It is to be regretted that this volumeter has been too recently added to our laboratory to enable me to report upon any extended tests of its efficiency. The obtaining of the volumes of cocoons has been considered as the least important of our many determinations, and has thus been for the present neglected. Another year I may be able to report more at length upon the instrument and its adaptability to the work for which it is intended.

Reel for testing Cocoons.

The filature value of a lot of cocoons may be indicated, if not accurately determined, by the unwinding and testing of the individual specimens. For this object, however, it is necessary to have a reel of special construction. Such a reel was first designed at Lyons by M. Dususeau, and another, somewhat modified, has since been constructed at Padua. The important features of such a reel are, first, that it shall accurately measure off successive skeins of 100 meters each; second, that it shall be capable of easy propulsion, either by foot or steam power; and finally, that it shall be provided with a certain and prompt stop-motion which shall, of preference, arrest the rotation of the reel automatically the moment the filament breaks.

The accomplishment of these desiderata has been reached in the apparatus mentioned. An ordinary sewing-machine frame, with its pedal and fly-wheel, is surmounted by a wooden top covered with copper and carrying a basin with a steam coil for heating the water which it contains. At the side of the basin opposed to the operator is a reel composed of ten bars, the periphery of which measures exactly 1 meter. At the right is the friction driving and stop-motion hereinafter described. At the left is a counter carrying four needles, the first of which indicates single turns of the reel, the second ten, the third one hundred, and the fourth one thousand revolutions. To the third is attached a pin which rings the small bell above the counter just before the completion of each one hundred turns, as a warning to the operator to slacken the speed of the reel.

The construction of the mechanism for promptly arresting the motion of the reel is accomplished by utilizing some of the features of Mr. Serrell's latest reel stop-motion. The axis of the reel is shown at I. This axis carries a friction wheel, C, which rests on the two friction wheels A and B, in the manner shown in the Plate VI, fig. 3. A and B are put in motion by a cord, as indicated by the dotted lines, driving C and the reel in the opposite direction. Slightly above the wheel C is a break-shoe, D; below the axis I is a lever, F, which is drawn upward in the direction shown by the arrow by the spiral spring E. The freedom of motion of the lever F is, however, restrained by the armature G of the magnet H. The running filament passes through the eye of a faller, and if the filament breaks an electric contact attached to this faller closes the circuit of the magnet, which attracts the armature and releases the lever F. This in turn is drawn upward by the spiral spring E and carries with it the friction pulley C, raising it from the driving pulleys A and B, and by pressing it against the break-shoe D, stops its rotation abruptly.

Between the basin and the reel is situated a moving guide which spreads the filament out on the reel in skeins about one-quarter of an inch wide. With this guide is combined the faller mentioned above.

Such are, in the main, the instruments of special construction used in the scientific testing of silk cocoons as conducted by us in our laboratory.

In all this work we have followed largely in the footsteps of the experimenters at Padua and Lyons, branching out where there seemed a chance for more original research.

PURITY OF RACE AMONG SILK-WORMS.

When Pasteur, nearly twenty years ago, undertook, at the request of the French Academy, to find a means of overcoming "the malady" of silk-worms he attacked the question as a novice who was not intimately acquainted with the work which he should perform. One of the first facts which attracted his attention was the absence of exactness in the science of silk-raising, or we might almost say the absence of science itself in the sericultural art. "Science," says Webster, "is a collection of the general principles or leading truths relating to any subject, arranged in systematic order." The facts were there, but they were a jumble of facts from which no system could be evolved. The most learned of the sericulturists did not agree in the fundamental principles of silk-raising, and in fact the more learned the savants the wider apart their theories and precepts. I speak of all this in the past tense, and yet how much better off are we to-day? Pasteur has succeeded in reducing the many diseases—many, more because of differences in local names than in symptoms—to four principal ones: The pébrine, flacherie, grasserie, and muscardine. Balbiani has even classified the corpuscles of the pebrine and Bassi the fungus of the muscardine, but to what end? The Pasteur system of selection has, to be sure, essentially blotted out the pébrine, through preventive but not through curative processes, but for the flacherie we have no means either of prevention or cure and it is to-day our greatest enemy. Still, we are in possession of many newly acquired facts, and a new era has evidently opened in scientific research which may ultimately lead us to that

ideal scientific condition where if trouble arise we may be able to deduce the cause and thus find the remedy.

But it is also true that the many researches are being made more from an industrial stand-point than a scientific one.

The first question asked when a newly discovered worm appears is not, "What are its most nearly allied genera and species?" but, rather, "What is the value of the cocoon? Will it reel? Can it be carded and made into schappe?" This spirit of industrial enterprise has led Mr. Natalis Rondot, than whom no one is better suited to direct the work, to obtain and have sent to France great numbers of wild and cultivated silk-worms from all parts of the world.

Among the more recent importations of M. Rondot are thirty-two races from China in 1887 and thirty-three in 1888, from the same country. These eggs were delivered to M. Maillot, director of the Montpelier (France) Experiment Station, for examination and study. Of the 1887 races four were very corpuscular and six slightly so, or more than 30 per cent. showed pébrine. In the 1888 races fourteen, or over 45 per cent., showed corpuscles. This should set at rest the dispute as to whether the pébrine exists in China. As to its effect on the crop, that is another question.

Of the 1887 races but two remained annual, all the others being either in part or wholly bivoltin. On the reproduction of these two races in 1888 one of them became bivoltin, while the other remained annual and showed increased strength in the worms and increased size in the cocoons.

"Purity of race," says Maillot in his report* on these educations, "comprehends identity of characteristics, especially in the color of the skin, the molts, the number of crops per annum, the color of the silk ducts, the form and the color of the cocoons, their weight and richness in silk, and finally the number of doubles."

An examination of the details of his experiments fail to reveal a single race which, when tried in this severe balance, was not found wanting.

The principal differences in these Chinese races are the variations in the markings of the larvæ, and even in this one particular there is very little regularity or purity. Thus in one sample we find bluish-white worms mixed with worms having black stripes, or again with worms of a somber hue. Some of them have masks (a name which M. Maillot applies to the small spot above the head) and some of them do not. These variations and others run through all the races, and sometimes there will be three or four different kinds of markings among the specimens of one lot. There is, in addition, a lack of uniformity in the color and shape of the cocoons, many lots giving white and green cocoons indiscriminately.

The state of silk culture in China may, in a certain measure, be deduced from these observations. It is impossible to estimate the quantity of silk produced in that vast empire, but it is, we know, cultivated in small lots and the worms are cared for with a sort of religious veneration. It is, perhaps, to these facts that is owing the slowness with which the pébrine has spread among Chinese silk-worms. We have heard of it for years, but still it does not seem to attain the proportions of an epidemic as it did in Europe thirty years ago.

*Compte-Rendu des Travaux de la Chambre de Commerce de Lyon, 1887, Lyons, 1888, p. 217.

A study of ten races received from Japan shows how much better are the sericultural affairs of that country. Here all the races were annual, having four molts; the eggs were received in perfect condition and hatched with remarkable uniformity. They had neither the pébrine nor the flacherie, and the cocoons, which were white in six lots and green in four, were perfectly homogeneous in the different lots both in color and form.

The Montpelier Experiment Station has, nevertheless, succeeded in rearing eggs from this heterogeneous Chinese mass which it is hoped will lead to the introduction of several valuable races. By a series of selections the races will be purified in the respects which have been noted above.

It must not be presumed, however, that the French and Italian races, even those of the best houses, are entirely free from faults in this respect. On the other hand, every silk-raiser who has utilized the eggs furnished by this Department has noticed a variation in the markings of the worms, more particularly by the admixture of striped and dark specimens. It is therefore not the intention of the French experimenters to neglect the European races in their work of purification, but they are taking those also and very carefully selecting them so that there may be absolute uniformity in the worms and their products.

REPORTS OF AGENTS.

REPORT ON VARIOUS METHODS FOR DESTROYING SCALE-INSECTS.

By D. W. COQUILLETT, *Special Agent.*

LETTER OF SUBMITTAL.

LOS ANGELES, CAL., *November* 13, 1888.

SIR: I herewith submit a report of some of the work done and observations made under your instructions during the past season.

The treatment with hydrocyanic acid gas for the destruction of scale-insects, described in my last report to you, is now coming into more general use, both by those who have obtained patents on their fumigators and by private individuals who use fumigators of their own devising. I learn that some of those who were among the first to obtain a patent on fumigator are claiming that their patent also covers the process of fumigating with hydrocyanic acid gas; but this claim is evidently erroneous, since the Patent Office decided a few years ago, before any of these persons had obtained a patent, that the Hatch patent referred to in my former report covers this process, and as the patent has expired the process becomes public property, and can not again be patented. There is, therefore, nothing to prevent any person from using this process, so long as he does not infringe on some of the patents in constructing a fumigator for his own use.

As heretofore, I am under special obligations to yourself for suggestions and instructions.

Respectfully,

D. W. COQUILLETT.

Prof. C. V. RILEY,
United States Entomologist.

THE GAS TREATMENT FOR SCALE-INSECTS.

This treatment is now coming into more general use, and is giving good satisfaction. A company has been organized for the purpose of manipulating the Culver fumigator (described in my report to Professor Riley, published in the annual report of the Department for the year 1887, page 129). Several private individuals

are also using or getting ready to use this gas treatment on their citrus trees by the use of fumigators of their own devising.

Since the publication of the above-mentioned report three papers on this subject have been published, one by Mr. F. W. Morse, as Bulletin 79 of the University Experiment Station of California; another in the *Pacific Rural Press* for August 25, 1888, by Mr. W. G. Klee, our State inspector of fruit pests; and a third in Insect Life for August, 1888, by the writer.

Mr. Morse's paper gives the results of various experiments made by himself, in which he corroborates the statements made by myself in the report referred to above, that the hydrocyanic acid gas may be rendered harmless to the trees confined in it either by using the potassium cyanide dry, or by using an aqueous solution of it and passing the gas through sulphuric acid; he agrees with me that the method of passing the gas through sulphuric acid is the best one, but recommends using pumice-stone saturated with sulphuric acid instead of using the acid alone.

It is very doubtful that this would be any improvement over my method. The acid used in saturating the pumice-stone could never be used again for generating the gas, so that there would be the additional expense for this acid. Moreover, the experience of Mr. Klee, given in his paper referred to above, would indicate that this method is quite uncertain. His experience is given in the following words:

"The tests were made during all kinds of weather, from 60° to 80° F. in the shade, and during calm as well as windy weather, and when the drier was well charged with sulphuric acid no harm was done to the trees, and even young fruit, during a confinement of forty minutes at the noon hour, was unaffected. On the other hand, when for the lack of sulphuric acid the drier was not sufficiently charged, serious harm resulted to the foliage, and the leaves fell off in the course of a couple of days. This was especially the case when the operation was done during the middle of the day, but bad effects resulted also when it was done in the evening as late as 7 o'clock, at a temperature of 60° F."

There is nothing to indicate when the drier should be recharged with the sulphuric acid, and this defect is wholly obviated by the use of this acid alone.

The persons operating the Culver fumigators adopted my method of passing the gas through sulphuric acid, and several weeks ago they treated about eighty orange trees without injuring the foliage, notwithstanding the fact that the work was done during very hot weather and at all hours of the day. So long, therefore, as such results as these can be obtained by using the sulphuric acid alone, it would be unwise to go to the additional expense necessary in using the pumice-stone saturated with the acid.

The drying vessel of the generator should have a diameter of about 8 inches and a height of about 10 inches, and the leaden pipe which conveys the gas from the generator should reach to within an inch of the bottom of this vessel. When ready to begin operations the bottom of this vessel should be covered to a depth of 2 or 3 inches with sulphuric acid, but this depth must be regulated by the pressure of the gas, acid being added until the gas no longer passes freely through it but is forced back through the acid in the vessel over the generator; a small quantity of the gas in the drying vessel should then be withdrawn until the gas passes easily through the acid in this vessel.

It was found necessary to insert a safety-valve either in the top of the generator proper or in the leaden pipe which conveys the gas to the drying vessel. This valve is so constructed that pressure from within closes it, while pressure from without forces it open. After all of the gas has been produced from a given quantity of materials the generator still remains full of the gas, and as this becomes dissolved or absorbed by the liquid residue in the generator a partial vacuum is produced, and this has the effect of drawing some of the acid out of the drying vessel and emptying it into the generator. The use of the safety-valve referred to above entirely obviates this, the valve opening and allowing the air to rush in whenever a partial vacuum is formed in the generator.

Mr. O. H. Leefeld, of Orange, has constructed and is using an apparatus and tents of his own devising. The apparatus consists of a strong frame-work mounted upon the running-gears of a common lumber wagon; this frame projects slightly behind the hind wheels, and in the middle of the hind end is erected a tall mast, to the top of which is fastened a cross-piece strengthened by two braces attached at one of their ends to the mast. To either end of this cross-piece is suspended a tent, to the bottom of which is attached a circle of gas-pipe; the ropes which operate the tent are fastened to its peak, and also to the circle of gas-pipe at the bottom of the tent, and are passed through pulleys at the end of the cross-piece of the mast and through other pulleys attached to the top of the mast; and from these the ropes pass to the ground. In drawing the tent off of a tree the ropes fastened to the circle at the bottom of it are first drawn downward, drawing the tent upward and at the same

time turning it inside out; after it has been drawn upward until the circle of gas-pipe is above the top of the tree, the rope attached to the peak of the tent is then pulled downward until the tent is raised above and entirely off of the tree.

Mr. Leefeld's generator and blower (for generating the gas and distributing it inside the tent) are so arranged that by opening or closing a series of shut-offs he is able to operate the two tents with only one set of apparatus. Altogether, it is a very clever arrangement, and gives good satisfaction.

Mr. Leefeld purchased his cyanide in Philadelphia, Pa., at the rate of 39 cents per pound for 500 pounds, and the freightage, etc., amounted to 5 cents per pound, making a total cost of 44 cents per pound. It is said to be the best grade of cyanide (*i. e.*, next to the C. P.) manufactured by Powers & Weightman, and came in 10-pound tin cans. The cyanide is in pieces, having a square inch or less of surface, and the pieces are about an inch thick. It dissolves in water in about an hour, by being frequently stirred; the solution is of an olive-gray color, and the color is not changed after standing for a few days. The proportions are 5 pounds of the cyanide to 1 gallon of water, but Mr. Leefeld writes me that he has succeeded in dissolving this amount of the cyanide in three-quarters of a gallon of cold water.

More water than is absolutely necessary for dissolving the cyanide in should never be used. I have added water to solutions of the different brands of cyanide, until the solutions contained cyanide at the rate of 5 pounds to one gallon and 4½ pints of water, but when this was used so that the same quantity of the dissolved cyanide was taken as when it had been used at the rate of 5 pounds of the cyanide in 1 gallon of water it did not produce as good results; this was doubtless owing to the fact that much of the gas had been dissolved and retained in the liquid residue in the generator.

The persons operating the Culver fumigators purchased their cyanide of a wholesale dealer in this city, paying for it 65 cents per pound for 25 pounds. This cyanide also came in 10-pound tin cans, and was in large circular cakes about three-quarters of an inch thick, each cake bearing the stamp of "C. P. & Co., New York." Five pounds of this cyanide dissolves in a gallon of water with occasional stirring; the solution is of an olive-gray color, and the color is not changed after the lapse of a few days. Each of the cans containing this cyanide is labeled "Cyanuret of Potassium," this being the old name for cyanide.

It was found necessary to use this cyanide solution somewhat stronger than indicated in the table given in my report above referred to. Following is a copy of the table of proportions which they found necessary to use with this brand of cyanide:

Height of tree.	Diameter of tree.	Cyanide solution.	Sulphuric acid.
Feet.	*Feet.*	*Fluid ozs.*	*Fluid ozs.*
8	6	7	4
10	6	8	5
10	8	14	8
10	20	22	12
12	6	10	6
12	8	16	9
12	10	25	13
12	12	35	19
12	14	48	25
14	12	43	23
14	14	58	30
16	14	67	35
16	16	90	47

The relative strength of this brand of cyanide as compared with the best grade of the Powers & Weightman cyanide (such as may be purchased in this city at retail, in glass jars, at about 80 cents per pound) may be gleaned from the fact that 9 fluid ounces of the latter solution are equivalent to about 14 fluid ounces of the former. The Powers & Weightman cyanide purchased by Mr. Leefeld, referred to above, was found to be not so strong as the grade the same firm puts up in glass jars for the retail trade.

Beside the Powers & Weightman and the C. P. & Co. cyanide referred to above, I have tested two other brands. One of these is manufactured by Mallinckrodt & Co., of Saint Louis, Mo.; it is nearly as strong but not quite as easily dissolved as the Powers & Weightman cyanide in glass jars, and is put up in tin cans holding 1 pound each; it retails in this city at the same price as the Powers & Weightman in glass jars. This is the only cyanide I have used, an aqueous solution of which changes color after standing a short time; when first dissolved the solution is of

the usual olive-gray color, but after standing a few hours it assumes a reddish-brown color. It is also the only cyanide I have used which exhales a strong odor of ammonia while it is dissolving in cold water.

The other brand of cyanide referred to is manufactured by Hansen, Van Winkle & Co., of Newark, N. J.; it is their No. 2, fused, and they offer to furnish at the rate of 32 cents per pound net for 100 pounds. I experienced considerable difficulty in dissolving this cyanide in cold water, the solution being occasionally stirred. Each pound of this cyanide when dissolved adds only 6 fluid ounces to the solution, whereas 1 pound of each of the other brands adds 8 fluid ounces to the solution. The aqueous solution requires just twice the amount of sulphuric acid to evolve all of the gas from it as is required by the other brands. I made two tests with this cyanide on orange trees infested with the Icerya, using it in one of the tests three times as strong as indicated in the table given above, but it produced no visible effects upon the Icerya. This brand is too much of the nature of the "mining" cyanide to be successfully used for the production of hydrocyanic acid gas.

I have also tested a brand of potassium cyanate (KCNO) manufactured by E. Merck, of Darmstadt, Germany, and labeled "40 per cent." (presumably of pure KCNO); it was put up in glass jars, one pound in each, and retails in this city at the rate of 65 cents per pound. It is not quite so soluble in cold water as the Powers & Weightman cyanide, and the solution requires one-third more sulphuric acid to evolve all of the gas from it. When used in the same proportion as the above cyanide solution, it was found to be only about one-half as effective.

When some of the aqueous solution of either of the above brands of cyanide or cyanate gets upon the hand, and water is applied for the purpose of washing it off, it produces a soapy feeling to the touch, but does not appear to injure the skin.

At the request of several fruit-growers of Orange I went to that place on the 14th of last May and treated one lemon and five orange trees with hydrocyanic acid gas, passing it through sulphuric acid. The trees were each about 10 feet tall by 8 feet in diameter; they were badly infested with the red scale (*Aspidiotus aurantii*, Maskell), and were among others equally infested. The best grade of Powers & Weightman cyanide in glass jars was used, and was dissolved in cold water at the rate of 5 pounds of the cyanide to each gallon of water; 9 fluid ounces of this solution and 6 fluid ounces of sulphuric acid were used for each tree. The trees were treated between the hours of 11 o'clock a. m. and 5 o'clock p. m., while the sun was shining brightly; five of them were confined in the gas for half an hour and one of the orange trees was confined only twenty minutes. Owing to the fact that the drying vessel of the generator I used was much too small (having a diameter of only 3 inches when it should have been at least 8 inches) the trees were quite severely injured, although all of them subsequently recovered.

These trees were examined occasionally by the owner of them, Mr. I. L. Collins, and under date of May 30 he writes me as follows:

"DEAR SIR: Since writing to you a pretty thorough examination of the trees was made by Dr. Wall, of Tustin, and Mr. Alward; they failed to find a single live scale. J. B. Parker and myself also made one yesterday, and found only one live red scale, and that was on an orange quite near to the ground. * * * All of the young growth on the lemon and oranges was killed; a very small percentage of the leaves on the oranges, but fully one-half of those on the lemon, were killed. Very few oranges fell off from that cause, as more than 50 per cent. of the little oranges fall off every year. The damage to the trees is nothing if the bugs can be killed."

Dr. W. B. Wall, of Tustin, who is a very close observer, and well able to judge between a living and a dead red scale, writes me as follows, under date of August 10:

"DEAR SIR: I visited the trees at Collins' twice after you were there, at intervals of ten or fifteen days, but did not find a living scale at either visit."

Again, under date of August 15, he writes:

"DEAR SIR: I examined the trees at Collins' yesterday; the work is highly satisfactory, the trees treated are of a healthy, deep-green color, while all the others look sickly, are yellow, and shedding their leaves. There are a few living red scales on the fumigated trees, but these have evidently been brought on them since they were treated; the most of them are small—say a quarter grown—one or two on a leaf here and there."

In conversation with these gentlemen they informed me that the gas had been just as effectual on the trees confined in it only twenty minutes as it was on those confined in it for half an hour.

ARSENIURETTED HYDROGEN GAS AS AN INSECTICIDE.

During the past season I have paid especial attention to the preparation and use of arseniuretted hydrogen gas (AsH_3) in destroying scale-insects infesting trees and plants, by the use of a tent, as in the treatment with hydrocyanic acid gas previously described; but the results have not been as good as I had reason to expect.

This gas is not so injurious to the foliage of trees confined in it as is the undried hydrocyanic acid gas, and its effects upon the insects are not so early manifested as when the latter gas is used. Thus, when a tree is treated with a sufficient quantity of the arseniuretted hydrogen to prove fatal to all of the Iceryæ infesting it, many of the latter will be as lively as ever the moment the tent is removed from the tree, and some of them will still be alive twenty-four hours later, but will perish during the next twenty-four hours.

The gas was generated by acting upon zinc with commercial sulphuric acid in the presence of an aqueous solution of white arsenic (As_2O_3).

The undiluted sulphuric acid produces no effect upon pieces of ordinary sheet zinc, even after the lapse of eighteen hours; when, however, some of the arsenic solution is added, brisk action begins after the lapse of a few seconds. The gas is generated the most rapidly when 5 fluid ounces of the solution is used to each fluid ounce of sulphuric acid; this is sufficient for 1 ounce by weight of zinc clippings. With the same proportions of sulphuric acid and zinc clippings, if more of the solution than above indicated is used, the process will be delayed; while if less is used than indicated above, all of the zinc will not be acted upon. A large proportion of the acid does not in any way accelerate the process of evolving the gas; while if less acid than I have indicated is used all of the zinc will not be acted upon. In my experiments, whenever I did not use a sufficient quantity of the arsenic solution in proportion to the zinc and acid the deficiency was made up of pure cold water.

I first used the sheet zinc cut into pieces about three-quarters of an inch wide by 2 inches long; these will dissolve in sulphuric acid and the arsenic solution in fifteen minutes, and the process is not hastened any when smaller pieces of the zinc are used.

The action of the acid and the arsenic solution is most rapid when the acid is first added to the zinc, and the arsenic solution added afterwards; when this process is reversed, and the arsenic solution is first added to the zinc and the acid added afterward, the action of these materials will be retarded one-third the length of time previously required.

I had some sheet zinc melted and poured into a vessel of cold water, for the purpose of obtaining granulated zinc in small pellets or globules; but the operator did not pour the molten zinc from a sufficient height, and consequently only obtained irregular pieces of sheet zinc scarcely thicker than writing-paper. When these pieces were used in the same proportion as the zinc clippings mentioned above, just twice the length of time was required for the acid and arsenic solution to dissolve them as was required by the clippings.

My next attempt at obtaining granulated zinc was more successful, the molten metal being poured into the water from a height of 14 feet; this produced small pellets and pieces of zinc of various sizes and shapes. When these were used in the same proportions as the zinc clippings referred to above, the same length of time was required for the acid and arsenic solution to dissolve them as when the clippings were used. Nothing is gained, therefore, by granulating the zinc, except that it is more convenient to use in this form than are the clippings.

The aqueous solutions of arsenic were prepared by simply boiling the white arsenic in water for about half an hour. When the solution contained an ounce by weight of arsenic to 18 or more fluid ounces of water, nearly all of it remained in suspension for several days; but if less water than this was used, more or less of the arsenic would settle to the bottom of the vessel when the solution became cold. When a quantity of the hot solution was poured into a cold vessel some of the arsenic would be deposited, forming a coating over the inside of the vessel; and this also occurs, but to a less degree, when the cold solution is poured into any vessel of the ordinary temperature of the air.

Since the arseniuretted hydrogen is formed only when the arsenic in solution is in immediate contact with the hydrogen produced by the zinc and sulphuric acid, at the moment that the hydrogen is generated, it follows that in preparing the former gas no exact proportion of the materials used can be followed by reason of the fact that all of the arsenic in the bottom of the solution, next to the zinc and acid, may become exhausted, while that in the upper portion of the solution will not have been acted upon, not having been in contact with the hydrogen when the latter was first generated; more or less of the free hydrogen will thus escape as such, while some

of the arsenic will still remain unchanged in the generator after all chemical action has ceased.

My first experiments with this gas were made upon Icerya-infested orange trees which were suffering for the want of water, as well as from the attacks of these insects; but these trees still possessed no small degree of vigor, very few of the leaves, and none of the fruit, having fallen from them. The Iceryæ infesting these trees, although alive and many of them were crawling about, still did not possess that plump, vigorous appearance so characteristic of those infesting healthy, well-kept trees.

Subsequent experiments made upon perfectly healthy trees and insects showed that when the gas was used strong enough to have proved fatal to all of the Iceryæ on the neglected trees it did not kill one-half of those on the vigorous trees. This clearly disproves the theory that has been advanced by a few casual observers, that the scale-insects thrive best upon sickly trees; if this was really the case the Iceryæ infesting these neglected trees would have been more vigorous than the others, and would have required a stronger dose of the gas before it would have proved fatal to them, but as stated above this was not all the case.

This brings us to the interesting question as to whether it would not be advisable to withhold water from the infested orange and lemon trees for several months at the proper season of the year, and then apply the insecticide, following it with a thorough irrigation. In this way the vitality of the scale-insects would be so much reduced that the effects of the insecticide would be more fatal to them than if the trees had been irrigated as usual; whereas if not carried too far no permanent injury to the trees will be likely to follow. The trees which I experimented on in July had not received any water directly since the rains of the preceding winter, but as there was a well-irrigated orange grove adjoining them they evidently received some water from this source. Several of the trees in the same plat as those I experimented on, but situated 4 or 5 rods farther from the irrigated grove, were irrigated in the month of September, two months after my experiments were made, and these shortly afterward started into a vigorous growth.

This, however, is the phase of the question which I must leave to the fruit-growers for them to decide. It is, of course, only applicable to trees growing in districts where irrigation is practiced.

The gas-generator I used in my experiments consists of a leaden vessel in the form of a cylinder, having a diameter of 8 inches and a height of 20 inches; the upper end narrows to a diameter of 2 inches, and is furnished with a screw coupling attached to a piece of rubber hose leading to the tin pipe, by which the acid and gas are drawn out of the upper part of the tent by means of a Cummings blower. The materials for generating the gas were put into the generator one after the other, and the coupling then screwed on; the gas as generated passed out of the top of the generator and through the rubber hose into the pipe leading from the tent to the blower, and by turning the latter the gas and air are drawn through it, and by a second tin pipe are forced into the lower part of the tent. This second tin pipe simply enters the tent below, while the one by which the air and gas are drawn out of the tent is furnished with an elbow reaching nearly to the top of the tree inclosed by the tent; thus by simply turning the blower the air and gas are drawn out of the upper part of the tent and again forced into it below, by which means the gas is thoroughly circulated inside of the tent.

In all of my experiments with this gas the residue remaining in the generator after all action of the materials had ceased was of a deep-black color, and much heat was produced during the generating of the gas.

The following is an account of the more important of these experiments; those numbered 140 to 148, inclusive, were on neglected trees:

(140) Boiled for half an hour 24 ounces by weight of white arsenic (As_2O_3) in 240 fluid ounces of water; the solution measured 204 fluid ounces. About 6 ounces by weight of the arsenic remained as an incrustation over the bottom of the vessel in which it was dissolved, and three days later an equal quantity of the arsenic had settled to the bottom of the vessel containing the solution.

Eight fluid ounces of commercial sulphuric acid (H_2SO_4) were added to 8 ounces by weight of sheet zinc cut into small pieces, and to these were added 40 fluid ounces of the above arsenic solution. The gas was passed through a Cummings blower, as described above, the blower being turned for five minutes after the generating of the gas began. Tent inclosed about 57 cubic feet of space. Test made July 2, from 9 to 9.30 a. m.; sun shining. Examined tree July 19; found only two living Iceryæ; leaves uninjured.

(142) Ten fluid ounces of sulphuric acid were added to 10 ounces by weight of the zinc clippings, and to these were added 50 fluid ounces of arsenic solution 140. Blower turned ten minutes. Tent inclosed about 22 cubic feet. Test made July 3, from

10.30 to 11 a. m.; sun shining. Examined tree July 19; found no living Iceryæ; three-fifths of the leaves and a few tender twigs at the very top of the tree were killed.

(144) Thirty fluid ounces of the arsenic solution 140 were added to 6 ounces of zinc clippings, and to these were added 6 fluid ounces of sulphuric acid. Blower turned five minutes. Tent inclosed about 57 cubic feet. Test made July 6, from 10 to 10.30 a. m.; sun shining. Examined July 24; found only one Icerya; leaves uninjured.

(145) Twenty-one ounces of the arsenic solution 140 were added to 7 ounces of zinc clippings, and to these were added 8 ounces of sulphuric acid. Blower turned five minutes. Tent inclosed about 88 cubic feet. Test made July 9, from 10 to 10.30 a. m.; sun shining. Examined July 24; found no living Iceryæ; leaves uninjured.

(146) Seven ounces of sulphuric acid were added to 6 ounces of granulated zinc (prepared as described above), and to these were added 15 ounces of the arsenic solution 140 diluted with the same quantity of cold water. Blower turned five minutes. Tent inclosed about 123 cubic feet. Test made July 12, from 2.15 to 2.45 p. m.; sun shining. Examined July 24; found about two dozen living Iceryæ; leaves uninjured.

(147) Boiled for forty minutes 8 ounces of white arsenic in 184 fluid ounces of water; the solution measured 128 fluid ounces. After the lapse of several days only a small quantity of the arsenic had settled to the bottom of the vessel containing the solution.

Seven ounces of sulphuric acid were added to 6 ounces of the granulated zinc, and to these were added 21 ounces of the above arsenic solution and 14 ounces of water. Blower turned five minutes. Tent inclosed about 88 cubic feet. Test made July 20, from 9.30 to 10 a. m.; cloudy. Examined August 6, and found only two living Iceryæ, at the very top of the tree; leaves uninjured.

(148) Nine ounces of sulphuric acid were added to 8 ounces of granulated zinc, and to these were added 18 ounces of the arsenic solution 147 and 27 ounces of water. Blower turned five minutes. Tent inclosed about 137 cubic feet. Test made July 20, from 10.25 to 10.55 a. m.; cloudy. Examined August 6, and found only three living Iceryæ; leaves uninjured.

(152) Three ounces of sulphuric acid were added to 2½ ounces of granulated zinc, and to these were added 6 ounces of the arsenic solution 147 and 9 ounces of water. Blower turned five minutes. Tent inclosed about 42 cubic feet of space on a rose-bush. Test made August 14, from 10.15 to 11 a. m.; sun shining. Examined September 4; about three-fourths of the Iceryæ were still living; one-half of the leaves on the rose-bush were killed.

(153) Four ounces of sulphuric acid were added to 3 ounces of the granulated zinc, and to these were added 6 ounces of the arsenic solution 147 and 14 ounces of cold water. Blower turned five minutes. Tent inclosed about 32 cubic feet on an orange tree. Test made August 14, from 3.15 to 4 p. m.; sun shining. Examined September 3; about three-fourths of the Iceryæ were still living; leaves uninjured.

In this and all of the following experiments the trees were healthy and vigorous, and the Iceryæ infesting them were correspondingly so.

(154) Five ounces of sulphuric acid were added to 4 ounces of the granulated zinc, and to these were added 8 ounces of the arsenic solution 147 and 17 ounces of cold water. Blower turned five minutes. Tent inclosed about 69 cubic feet. Test made August 14, from 4.30 to 5.15 p. m.; sun shining. Examined September 3; about four-fifths of the Iceryæ were still living; leaves uninjured.

(155) Boiled for forty minutes 10 ounces of white arsenic in 208 fluid ounces of water; the solution measured 128 fluid ounces. Six days later but little of the arsenic had settled to the bottom of the vessel containing the solution.

Ten ounces of sulphuric acid were added to 9 ounces of the granulated zinc, and to these were added 30 ounces of the above arsenic solution and 20 ounces of water. Blower turned five minutes. Tent inclosed about 170 cubic feet. Test made August 15, from 4.30 to 5.15 p. m.; sun shining. Examined September 3; about three-fourths of the Iceryæ were still living; leaves uninjured.

(170) Boiled for half an hour 5 ounces of white arsenic in 220 fluid ounces of water; the solution measured 176 fluid ounces.

Nine ounces of sulphuric acid were added to 8 ounces of zinc clippings, and to these were added 30 ounces of the above arsenic solution and 15 ounces of water. Blower turned nearly continuously during the time of making the test. Tent inclosed about 32 cubic feet. Test made October 12, from 3.30 to 4 p. m.; sun shining. Examined November 8; about three-fourths of the Iceryæ were still living; leaves uninjured.

(171) Fifteen ounces of sulphuric acid were added to 14 ounces of zinc clippings, and to those were added 48 ounces of the arsenic solution 155, 8 ounces of arsenic

solution 170, and 20 ounces of water. Blower turned almost continuously during the time of making the test. Tent inclosed about 69 cubic feet. Test made October 12, from 4.30 to 5 p. m.; sun shining. Examined November 8; about one-fourth of the Iceryæ were still living; leaves uninjured.

As several persons have sent me very erroneous calculations concerning the number of cubic feet of space inclosed by the tent covering a tree of a given diameter and height, it may not be out of place here to give briefly my method of making at least an approximate calculation of the cubical contents of the tent. The latter, when on a tree, is in the form of a cylinder, with the exception that one of the ends is dome-shaped, instead of being squarely truncated; to allow for this we simply subtract a few feet from the height of the tent, and multiply the remainder by the area of its base; the latter is found by multiplying the square of its diameter by the decimal fraction .7854. Thus, to find the cubical contents of a tent inclosing a tree 10 feet high by 6 feet in diameter, we first multiply the square of 6 by .7854, which gives about 28.27 square feet; subtracting 1½ feet from the height of the tent, to allow for the dome, we next multiply the remainder by 28.27, which gives us a fraction over 240 cubic feet as the solid contents of the tent.

THE RESIN COMPOUND FOR SCALE-INSECTS.

This compound is now being quite extensively used in this part of the State for the destruction of scale-insects of every description and is giving good results. It was first used by Mr. Albert Koebele, one of the entomological agents of this Department, and he has given an account of it in his report to Professor Riley, published in the annual report of this Department for the year 1886, page 569, experiment 157. The proportions of materials given in this experiment, however, are not quite correct. The following proportions, based upon many experiments which I have made with this compound, and also upon the experience of others who have used it, will give much better results:

Caustic soda, 1 pound.
Resin, 8 pounds.
Water to make 32 gallons.

The caustic soda is first dissolved by boiling in about a gallon of water; when dissolved, one-half of the solution is taken out and the resin added to the remainder and boiled until dissolved, after which the balance of the soda solution is added very slowly. The mixture is then boiled over a hot fire, being stirred almost constantly, and when cooked sufficiently it will assimilate with cold water like milk, which it much resembles. A sufficient quantity of water should then be added, the mixture being thoroughly stirred during the adding of the water; it should then be strained through a fine sieve, or through a piece of thin and rather open cloth, otherwise there will be some difficulty in forcing it through a spraying nozzle.

The main points to be observed in the preparation of this compound are to have a hot fire and to stir the mixture about constantly during the cooking, to prevent burning.

The success attending the use of this compound depends largely upon the fineness of the spray and the thoroughness of applying it. I have seen orange trees that had been only lightly sprayed with it and not more than half of the Iceryæ were killed, while on other orange trees that had been thoroughly drenched with the same solution nearly all of these insects were killed. Many of the partial failures resulting from the use of this and some of the other washes may be traced to the fact that they have been used too sparingly. It is not enough to simply *wet* every part of the tree; it should be *thoroughly drenched*, or satisfactory results will not be obtained.

One of my correspondents, Mr. Henry H. Wheeler, of Pomona, has used this compound in the proportion of 1 pound of caustic soda, 10 pounds of resin, and water to make 40 gallons, and under date of September 28 he writes me as follows concerning it:

"DEAR SIR: Having used the resin compound for spraying orange and lemon trees affected with 'black scale,' I will send results as far as I can perceive them. In my orchard of about four hundred orange and eighty-four lemon trees there were three badly injured in looks and vitality, being completely covered by the black scale. Of the remainder, perhaps half a dozen needed spraying, all the rest being remarkably clean, healthy, and vigorous. Nevertheless, to be on the safe side, all have been sprayed. The trees are four years old from the bud, about 5 feet in diameter through the tops, and 5 or 6 feet high.

"Five barrelfuls, or about 200 gallons, were used, costing about a cent a gallon, or less than half a cent for each tree—$2 for the whole orchard. If a satisfactorily

working pump had been used, about three days would have sufficed for the preparing and applying of the wash, provided there should be no delay in cooking the compound, as there was in my case. One man can do the spraying, but it will take nearly twice as long as if two did the work.

"On the three badly affected trees a large portion of the bugs are dead, but not all, the young ones seeming to be the hardest to kill. One of these trees I sprayed a second time about two days after the first application, and a third time about a week after, and all of the bugs are not dead yet, nor the tree clean looking. Perhaps the results would have been better if more time had elapsed between the applications, for I notice that now, two weeks later, more scales are destroyed than I thought would be when I looked at the trees a day or two after the first and second sprayings. So I can not say from this experience that one, two, or even three applications will thoroughly rid a tree of black scales.

"Some think the fruit may be injured by the caustic soda, but as I accidentally sprayed my eye, with only a momentary smarting, I do not believe any foliage or fruit can be hurt.

"This is my experience in cooking the compound: As I had no large vessel only enough at one time for a barrel full was prepared. The first time I kept it boiling half a day, expecting according to directions that when it had boiled sufficiently it would mix with water; but it never would. At last I added a little more of the soda solution, and it came out all right. The second time I had to add more soda. The third time, by using about a pound and a half of soda to ten of resin, it came without any trouble. The fourth mess would not assimilate, so I added more soda solution; that made it dark and thick, like soft soap, so I thought more resin needed. Still it would not mix, so more soda was added, then more resin, and after adding soda once more I gave it up. Can you tell me what the trouble was? At no stage of the cooking would it mix with water. The fifth time I had to add more soda, and while it mixed with water it was darker, more like molasses. Still it was used and worked well.

"Although when prepared rightly it assimilated perfectly with water, making a milky substance free from sediment, still after emptying the barrel each time there was a caked sediment of a waxy texture which stuck onto the filters of the suction pipe, and getting into the tube, clogged the nozzle, causing a deal of delay."

One of the troubles experienced by Mr. Wheeler in making this compound resulted from the fact that as crude caustic soda is not always of a uniform strength, 1 pound of it will not always saponify 10 pounds of resin; for this reason I have recommended using only 8 pounds of resin to 1 of caustic soda, and several trials that I have made with the compound by using these proportions have in every instance resulted in producing the compound within an hour after the time that all of the materials were dissolved. If not enough caustic soda has been used, the compound while being cooked will produce large bubbles; whereas if a sufficient quantity has been used it produces very small bubbles which rise up in the vessel in a foam-like mass.

The trouble of the nozzle becoming clogged by the solution would doubtless have been obviated if the solution had been previously strained. I experienced the same difficulty with a Crofton nozzle I used, but after straining the solution through a piece of thin tarlatan cloth I had no more difficulty with the clogging of the nozzle.

Half a gallon of the solution would scarcely be sufficient to thoroughly drench an orange tree 5 feet tall by the same in diameter; I should have used at least *three times* this quantity in ridding a tree of this size of the Iceryæ.

Under date of October 15, Mr. Wheeler further writes me as follows:

"DEAR SIR: I have just again looked at the tree which I sprayed three times with the resin compound. A large portion of the black scale is dead, but not all. New growth has started at points, and the smut upon the foliage loosened, but the tree does not look much better. * * * The compound seems a good one, and if I can learn to make it without so much loss of time and material I shall probably use it next year. If it could be made within half an hour after the water boils, as I did once, and a nozzle used that didn't keep clogging, I would like it much. * * * I don't remember that there was much trouble from the plunger of the pump sticking, though I think a little; the most was free from the nozzle becoming clogged, requiring great pressure in pumping to overcome it.

"I will look once more at the fruit. No, as far as eyesight can judge, neither the fruit nor the new growth are injured a particle on the budding trees. I used a little from the bottom of the barrel—probably a little over strength—on a young seedling tree, and the leaves look a trifle curled (not burnt) as if from wilting, and I don't know but that is the reason, though I have watered it since.

"I should say, with a deal of confidence, that the wash is absolutely harmless to

the fruit and foliage; in fact, when it didn't injure my eyeball I didn't see (logically, not physically) how it could injure a green orange."

Mr. Wheeler also writes me that he purchased his materials from the Los Angeles Soap Company, of this city, and that the prices were as follows: Caustic soda, 4¼ cents per pound; resin, 2¼ cents per pound. At these rates, each gallon of the diluted wash, made according to the formula I have given above, will cost a little less than three-quarters of a cent for the materials.

The following are some of the experiments which I made with this compound during the past season:

(156) Resin, 8 pounds; caustic soda, 1 pound; water to make 30 gallons. Sprayed lightly on rose-bushes infested with the Iceryæ. This proved fatal to only about one-half of the Iceryæ; the bushes were uninjured.

Mr. Alexander Craw, of this city, sprayed a number of rose-bushes with this compound last winter, using 10 pounds of resin, 1 of caustic soda, and water to make 50 gallons; this was not strong enough, so he added more resin and caustic soda, until the proportions were about 10 pounds of resin, 1 of caustic soda, and water to make 40 gallons. The rose-bushes were very thoroughly sprayed with this solution, and nearly all of the Iceryæ were killed, while the bushes were uninjured. These bushes were situated in the immediate vicinity of infested orange trees, and about eight months later were about as thickly infested with the Iceryæ as when first sprayed.

(157) Resin, 8¼ pounds; caustic soda, 1 pound; water to make 38 gallons. Sprayed on an orange tree. About 90 per cent. of the Iceryæ were killed, while the foliage of the tree was uninjured. A dozen red scales (*Aspidiotus aurantii*, Maskell) were also upon this tree, and all but one of them were killed. Several weeks after the application the black smut still adhered to the leaves.

(158) Resin, 8¼ pounds; caustic soda, 1 pound; water to make 26 gallons. Sprayed on an orange tree. All of the Iceryæ were killed; leaves uninjured and still covered with the black smut seven weeks later. Three out of the six green oranges upon this tree had a brown spot burned into their under side where the solution had collected in a large drop; this may have been produced by some of the solution in the bottom of the vessel which was stronger than the rest, as the solution had not been strained previous to being applied. Some of it was also sprayed on a peach tree, but did not injure the leaves. There were also several red scales and soft scales (*Lecanium hesperidum*, Linn.) upon the orange tree, and all of these were killed.

(164) Resin, 8¼ pounds; caustic soda, 1 pound; water to make 76 gallons. Strained the solution through a piece of tarlatan cloth and sprayed it on an orange tree. Nearly all of the young Iceryæ in the first and second stages were killed, but many of the older ones and nearly all of the adults escaped injury; leaves and fruit uninjured.

In making these experiments I used an aquapult pump and a Crofton nozzle. A figure of this pump is given by Professor Riley in the fourth report of the United States Entomological Commission, Plate XL, fig. 1; and a good idea of the nozzle may be gleaned from fig. 8, Plate XXI, of the same report. The Crofton nozzle has an eddy chamber in place of the hole or bore shown at *c* in the above-mentioned figure, and by turning the shut-off plug (B) a coarse or fine spray may be had at the will of the operator. This is an improvement over the Cyclone and San José nozzles, in both of which it is necessary to change the cap or piece containing the opening out of which the spray issues, in order to obtain a finer or coarser spray, as desired. The Crofton nozzle is furnished with two openings, each of which is almost large enough to admit the head of an ordinary pin; one of these openings is situated at the end, and the other on one side of the nozzle, and by turning the shut-off plug the spray may be made to issue from the end or from one side of the nozzle as desired. There is also a larger opening on one side of the nozzle, intended as a means for freeing the outlet of the eddy chamber when it becomes clogged, but I did not find this to operate very successfully. Whenever the outlet became clogged I found it necessary to take out the shut-off plug and remove the obstacle; but the nozzle seldom clogged when the wash had been previously strained.

THE COPPER MIXTURE OF GIRONDE AS AN INSECTICIDE.

On the 20th of last January I received the following letter from Professor Riley, under date of January 13:

"DEAR SIR: I learn from Mr. Scribner that Mr. A. B. Elder, of San José, reports that the 'Bordeaux mixture,' or 'Copper mixture of Gironde' recommended by the Section of Mycology of the Department for Grape-vine Mildew works well on trees

of all kinds as a scale preventive and destroyer. I should like to have you correspond with Mr. Elder and ask him the facts in the case, and, if it seems worth while, to conduct experiments yourself with this mixture."

Accordingly I wrote to Mr. Elder upon the subject, and received the following reply, under date of January 29:

"DEAR SIR: Yours of the 21st instant is to hand, and in reply will say that the compound for spraying fruit trees was used by me, and the results were good. I used the materials according to the circular of the Hon. Norman J. Colman, and I used it on willows and other useless bushes until I ascertained the proper strength; I then sprayed scale-infested trees with it, and the results were all that could be wished, and, in fact, effectual."

Thinking the subject worthy of a careful investigation I obtained the necessary materials and proceeded according to the directions given in "Circular No. 3, Section of Vegetable Pathology," reprinted on pages 328, 329, of the annual report of this Department for 1887.

I first dissolved 2 pounds of sulphate of copper (also known as *bluestone* or *blue vitriol*, $CuSO_4, 5H_2O$), in 2½ gallons of cold water; it dissolved in about an hour, with occasional stirring. I next slaked 3 pounds of quicklime (CaO) in half a gallon of water, and the next day added it to the above solution of sulphate of copper, stirring it thoroughly. On the following day I made several tests with it, the more important of which are as follows:

(161) Took 1 pint of the above sulphate of copper and lime mixture and diluted it with 13 pints of water; this was then strained through a piece of this tarlatan cloth, and about 2 fluid ounces of a semi-solid substance was removed. The liquid portion was sprayed upon an orange tree at 1.30 o'clock p. m., while the sun was shining. I examined it three weeks later, and found that only a few of the Iceryæ had been killed by the wash; the foliage was uninjured.

(162) Took 3 pints of the above sulphate of copper and lime mixture and diluted it with 11 pints of water; strained it through a piece of tarlatan cloth, and removed about half a pint of a semi-solid substance; the liquid portion was then sprayed upon an orange tree at 2 o'clock p. m., while the sun was shining. I examined it three weeks later, and found that about one-half the Iceryæ had been killed by the spray; foliage uninjured.

(163) Immersed into the undiluted sulphate of copper and lime mixture a branch of an orange tree infested with the Iceryæ; this formed a thick coating over the bark and leaves, somewhat resembling whitewash. Three weeks later this coating had cracked open in many places, and the Iceryæ beneath it were alive and apparently healthy; I could not discover that a single one of them had been killed by the mixture. I again examined it two weeks later; about five-sixths of the surface of the leaves and bark of this branch was still covered with this mixture; many Iceryæ had settled down upon it, and were apparently in a healthy condition. The foliage was uninjured.

It thus appears that the diluted wash, holding in suspension the more soluble portions of the mixture, is more fatal to the Iceryæ than is the thick undiluted mixture.

As the materials for the wash of the strength given above in experiment 162 costs in this city at the rate of 3 cents per gallon, and the wash proved fatal to only one-half the Iceryæ, I did not deem it advisable to use it any stronger, since the cost alone would have prohibited it from being used on a large scale.

ENTOMOLOGICAL NOTES OF THE SEASON OF 1888.

By MARY E. MURTFELDT, *Kirkwood, Mo.*

LETTER OF SUBMITTAL.

SIR: I inclose herewith the record of the more important of my observations on the history and habits of injurious and beneficial insects during the present season, and I take this occasion to express my thanks to you for determinations and other favors by which my work was greatly facilitated.

Respectfully, yours,

MARY E. MURTFELDT.

Dr. C. V. RILEY,
Entomologist U. S. Department of Agriculture.

GENERAL OBSERVATIONS.

Early vegetables, strawberries, and other herbaceous plants suffered considerably from the attacks of Cut-worms, among which the larvæ of *Agrotis saucia*, *A. subgothica*, and *A. telifera* were conspicuous. The climbing species, *Agrotis alternata*, *A. scandens* (?) and *Homohadena badistriga* also did considerable damage in cutting the foliage and blossom buds of fruit trees and grape and honeysuckle vines. We found that bits of old carpet or gunny sacks, crumpled or folded, made the most inviting traps for these worms, and an examination of these during the day-time seldom failed to reveal a considerable number of the worms enjoying the treacherous hiding places. This kind of trapping is no more trouble than and is much preferable to the application of poisons to or around the plants attacked.

Flea-beetles (*Phyllotreta vittata* and *P. zimmermanni*) were in this locality conspicuous for their scarcity during the entire season. This immunity is probably to be attributed in part to the extreme drought and consequent baking of the soil of the previous year, and, in the case of the last-named species, to the eradication of the weeds *Lepidium* and *Arabis*, which are the favorite food plants of its leaf-mining larvæ.

The Plum Curculio did comparatively little damage during the present season, although stone fruits abounded more than they had done for five years. The later peaches suffered most, principally from their punctures for food.

The Codling Moth did no appreciable damage throughout the State, so far as I can learn, and within my personal observation certainly not more than 5 per cent. of an unusually full crop was "wormy." A few enterprising orchardists of my acquaint nce were at the expense of procuring spraying apparatus and arsenic or Paris green. These were used liberally, in some cases disastrously for the orchards, and the owners were chagrined to learn, later on, that neighboring orchards, not treated, enjoyed an equal immunity from the apple worm.

The Army-worm (*Leucania unipuncta*) made its appearance in many parts of the State, and did considerable injury to grass and small grains. So far as I have been informed it mostly developed in the fields where first observed and did not migrate in companies. In Montgomery County, however, some ditching was done to check its incursions. In Saint Louis County it was quite destructive in the spring, not only on farms but in suburban gardens, cutting off the earlier plantings of sweet corn, and dwarfing the small plats of rye, oats, and sorghum sown for pasturage and chicken feed. A large proportion of the worms I collected were parasited by *Tachinæ* and *Ichneumonidæ*. The succeeding broods of these worms did not attract any attention. The moth is "always with us" and is more commonly taken during autumn than at any other season.

Leaf-cutting Bees (*Megachile*), which have been for a few years past such depredators on the beauty of our more delicately colored flowers as to rank them among first-class pests, were much less numerous the present season. I can only account for this on the theory that the frequent and heavy midsummer showers drowned the larvæ and probably to some extent the mature bees, since, with us, they had acquired the habit of using tunnels in the ground for their nests. I have frequently seen them carrying their floral filchings into these holes, but whether they themselves dig them (which does not seem probable, scarcely possible, indeed) or merely make use of the excavations of some other insect or spider, I have not been able to ascertain.

Grapta interrogationis, which with us feeds principally on the Elm, this summer attacked the Hop vines in and around Kirkwood to a ruinous degree. It also fed largely on the Hackberry (*Celtis*).

A Plague of Psylla lice.—For some years we have been greatly annoyed during the months of September and October by swarms of these insects (*Pachypsylla c.-vesiculum*) bred from small, blister-like galls on the leaves of a fine Hackberry tree, distant about 15 feet from the house. In their search for winter quarters they invaded kitchen and dining-room, hall and chambers, settling on table linen and food and on the beds, even making their way between the sheets, causing much discomfort and disgust. They are so small that wire screens were no barrier to their ingress. Recently the nuisance became insupportable, and with much reluctance the tree was condemned to the ax.

Chloridea rhexia on Geraniums.—The handsome larva of this handsome moth usually shows a preference for feeding in concealment, and until this year I had only reared it from the fruit of *Physalis viscosa*, the inflated calyx of which afforded it the requisite protection. This summer accounts were brought to me by several neighbors of certain "red worms" that were eating the blossoms of their geraniums. I presently obtained some and was much interested in observing the

colorational adaptation to the part of the plant on which they preferred to feed. Indeed, so brilliant were their colors that I failed to recognize them and took a description and preserved specimens in alcohol (which have lost their color, however, to a great extent), under the impression that I had something new. When the moths emerged about three weeks later I was surprised to recognize in them a species with which I had long been familiar. The only remedy employed was to pick them by hand from the infested flower trusses, and the eye required some practice before they were readily distinguished.

The Seventeen-year Cicada.—Passing across northern Illinois from Chicago westward, about the middle of August, the work of the Cicadas on the forest trees and orchards of that section of the State was so conspicuous as to occasion much remark from travelers. Many small trees, both oak and apple, were killed outright, and entire groves had the appearance of having been severely scorched by fire. The insects seemed to be more numerous, judging by their effects, than they were in 1871, when I remember making similar observations at the same time of that year.

SPECIAL STUDIES.

THE GRAPE SCALE.

(*Aspidiotus uvæ*, Comstock.)

Early in the spring a vine of Concord grape, standing in the middle of a row, was observed to be thickly covered with the pale, brown, and dingy white scales of a coccid, hitherto unknown in the vineyards of this region. Examination and comparison with descriptions convinced me that it was the species above named, first partially characterized by Professor Comstock in the Report of the Department of Agriculture for 1880. Specimens were sent to Dr. Riley, who concurred in the determination.

The infested vine was found to have made a much less vigorous growth than its neighbors during the previous year, and the old wood was so thickly incrusted with the scales as to have the appearance of being whitewashed. Several of the stems most severely attacked were killed outright. What was more singular was the fact that none of the adjacent vines—the nearest on each side not more than 12 feet distant—showed a single scale. This could only be accounted for on the hypothesis that the insect had been transported from some perhaps quite distant vineyard by a bird which had here first alighted and obtained a riddance of its small company. From the appearance of the scale it seemed probable that the insect had been developing and multiplying on this individual vine for several years, and it was remarkable that birds or some larger insects should not have conveyed it to some of the other vines.

Naturally it seems to spread very slowly, the newer broods fixing themselves just beyond the borders of those of the previous year, never advancing beyond wood of less than two years' growth and seemingly very partial to the shelter afforded by the loosened shreds of bark. Here, with their myriad slender beaks buried in the sap wood, they slowly but surely exhaust the vitality of the vine, as indicated by the diminished size and paler color of the foliage, inequality in the size and irregularity in the ripening of the fruit, and general unthriftiness. Upon lifting the scales about the middle of April from thirty to forty (as nearly as they could be counted) oval, pale-yellow eggs could be seen. From these the young lice began hatching on the 12th of May, and could be discerned slowly crawling about among the old scales and spreading over the unoccupied spaces. They are barely visible to the unaided eye, being scarcely one-tenth millimeter in length. Under a strong lens they are seen to be of elongate form and pale orange color, with darker head; beak not distinguishable. It was impossible to ascertain precisely the length of the time during which they were active, as they continued to emerge for some time, and it required more continuous observation than I was able to give at that time to settle the point. New scales were formed during the month of June, and early in July a few winged males appeared in a jar in which I had a few days previously placed some fresh sections of the infested stems. In this sex the body is ovate, of a dull orange color, with a darker dorsal thoracic band; wings hyaline, and stylet very long.

Professor Comstock describes the male scale as darker than that of the female and elongate, but unless my observations were at fault the pupæ were only covered by a circular white scale, similar to that covering the exuviæ of the female. I was not able to see any male in the act of emergence, so I will not be positive on this point. In the rearing jar even this sex was very sluggish and out of doors they entirely eluded my observations.

The subsequent development of this species has been very slow. Most of the females are but half grown, and the largest still retain their segmentation. I even found a few active individuals as late as the 20th of October. By carefully raising the bodies of some of the females—which are of a disk-like form and pale yellow color—the long and extremely tenuous beak can be partially or entirely extracted and a minute globule of sap will ooze up from the puncture. The powers of my microscope are not equal to the clear resolution of the groups of spinnerets or the conformation of the marginal plates and fringes, but I have no doubt they are correctly delineated in the cuts accompanying Professor Comstock's description. While this bark louse shows itself very injurious to the vine on which it has become established, it has not, so far as one may judge by the observation of a single season, very great powers of spreading from vine to vine. It is also comparatively easy to eradicate it by carefully burning the prunings and by washing the remaining stems in strong soap-suds to which has been added 1 tablespoonful of kerosene to a gallon of the suds. Wishing to learn more of the habits of the species I would not suffer all of the stems to be sponged, but all that were treated to the soap and kerosene mixture remained free from the scale throughout the season. Simultaneously with the hatching of the young coccids appeared a very active, though tiny, mite, which preyed upon them voraciously, and no doubt reduced their numbers at least one-half. I did not secure any Chalcid parasites, but from the appearance of some of the scales I have no doubt they were present, more especially as I bred this season a number of specimens of *Aphelinus* from the closely allied Rose scale. The beetles and larvæ of the Twice-stabbed Lady-bird (*Chilocorus bivulnerus*, Leach) were numerous on the vine and undoubtedly did effective work in clearing off the coccids.

THE CABBAGE CURCULIO.

(*Ceutorhynchus napi.*)

During the latter part of April Mr. Henry Schnell, of the Glasgow, Mo., small fruits and vegetable farms, wrote me concerning an insect that was proving very destructive to cabbage plants in his hot-beds. Specimens of the affected plants were inclosed, which were found to be punctured and fretted in the crown and along the principal veins, a large proportion of the plants being killed by these attacks.

A few days later I received from Mr. Schnell several specimens of a small, dark gray curculio, with the information that it was "the same insect that had destroyed a considerable number of his plants in the field, later in the season of the previous year." A package of young cabbage plants was also inclosed, almost every one of which was found to be punctured in the center or at the side of the crown, and contained a small white grub, which was boring downward into the root, its soft castings filling the tunnel in its rear and being often forced out through the entering fissure. Mr. Schnell wrote: "They have already ruined over one-half of 40,000 plants in my hot-beds, and I should like to be prepared to check their depredations another year. How would a good salt dressing do for the beds, after taking out the plants, to kill the larvæ that might be in the ground?"

In answer to the query I advised a thorough drenching with hot water instead of the salt application, which might prevent the growth of other plants, for which the beds would be needed after the cabbage was removed. Many of Mr. Schnell's first settings of plants in the field also wilted and died, as it was impossible always to select such as had not been stung. However, by destroying as far as possible all that showed signs of injury, and by thoroughly scalding the hot-beds, as he informed me later, he so reduced the numbers of the pest as to escape serious loss in his later plantings, and by the 1st of June both beetles and larvæ had completely disappeared.

The experience of my correspondent with this insect would seem to be unique, as it has not heretofore, so far as I can learn, committed any depredations to entitle it to a place in American works on economic entomology. It is to be hoped that this instance was, so to speak, a "sporadic" development and not a "first appearance" of what is destined to become a general pest.

Although unnamed in my collection until kindly determined for me last spring by Professor Riley, the species was not entirely unknown to me, as I had bred it several years before from larvæ boring the stalks of the wild Pepper grass (*Lepidium virginicum*) early in the spring. The original descriptions of this species not being accessible to me, I transcribe the following characterizations from my notebook:

Egg one-half millimeter in length, of oval form, almost transparent, very frail, deposited in a cavity drilled by the rostrum of the parent beetle.

Larva, when full-grown, from 4 to 5 millimeters in length and about 1¼ millimeters

in diameter, nearly cylindrical, tapering abruptly at either end. Incisions shallow, surface faintly wrinkled, with fine transverse and oblique impressed lines, with a slightly elevated, fleshy lateral ridge, ventral surface also ridged and papillated. Head about half the diameter of thoracic segments, nearly circular, bright golden brown with dark brown trophi. Feeds and rests in an extended or very slightly curved position.

Pupa not observed, inclosed in compact, nearly spherical earthen cell just beneath surface of the ground.

Beetle broad oval, from 2½ to 3 millimeters in length and 2 millimeters in diameter. Rostrum one-half the length of the body, stout, cylindrical, faintly grooved; antennæ elbowed, slender, but broadly clavate; eyes small, oblong, situated low down at the base of the rostrum. Thorax conical, cylindrical, the anterior edge projecting in a circular vein around the head. Elytra somewhat shouldered, folding down so closely over the body that the median line is scarcely visible. Thighs thickened on all the legs. Color, to casual observation, varying from silvery to dark gray. The integument is really dull black, but it is covered with a short, coarse, whitish pubescence, finest and densest on lateral and ventral surfaces, giving to them a somewhat lighter tint. The elytra are beautifully striated by the arrangement of the pubescence in fine longitudinal lines.

The beetles from the spring brood of larvæ emerged about the middle of June. I have not been able as yet to ascertain whether there is a second brood. Should there be, the larval habits would necessarily be somewhat different.

A NEW APPLE-TWIG BORER.

(*Elaphidion ocellata*, Hald.)

Early in September of last year (1887) a correspondent, who is a large orchardist in southern Missouri, sent me a lot of apple twigs containing the larvæ of a longicorn borer, which he informed me was proving very destructive to the recent growth of his young apple trees. My first impression was that the insect was *Elaphidion villosum* or *parellelum*, if there is really any difference between these two. A critical examination, however, revealed characters clearly distinguishing it from these species. The larvæ varied in length from 12 to 16 millimeters, those most nearly mature being 3 millimeters in diameter across thoracic segments. The segments were narrow, somewhat angulated, much wrinkled, with papillate elevations on dorsum and venter bearing interrupted corneous ridges; incisions very deep. Color, bright golden yellow. Head rather small, dark brown, and much like that of *E. villosum*. The most characteristic feature is the shield-shaped corneous plate, resembling that of the larvæ of *Oncideres cingulatus*, arising obliquely from the head and covering the entire dorsum of the first thoracic segment. The apex of this plate is roughened with dark brown stippling, presenting the appearance, to the eye but not to the touch of a small spongy pad. The stigmata are inconspicuous. Legs and prolegs entirely undeveloped.

These larvæ, having completely hollowed out the twigs in which they were working when received, were successfully transferred to fresh ones, into which they at once entered and began to bore hungrily. They devour not only the pith but the woody fiber, ejecting the granulated frass through pin-like holes cut through the bark at irregular intervals.

When winter set in, fearing that these larvæ might not be able to complete their transformations in the dry air of the house, I put the twigs containing them in a wire-cloth box and fastened it near the ground to a shrub in the garden.

Early in April I examined into their condition and found them healthy and unchanged. Not considering it probable that they would transform very early, if at all this season, I did not pay any further attention to them for three or four weeks, and was much surprised, on May 8, to find that all the beetles, three in number, were perfected, the pupal period being apparently very short.

The species proved to be, as I had anticipated, one not previously reported as injurious, and was kindly determined for me by Professor Riley as the one named at the head of these notes.

The beetle is of slender form, somewhat smaller than *E. villosum*, with bluish-black, densely punctate elytra, which are slightly but gradually constricted in the middle and notched at the tips. Thorax dull red, with a conspicuous black spot on each side of the median line. Head black, antennæ nearly equaling the length of the body, and under legs pale, reddish brown.

In July of the present year I received from Mr. Elliott a second consignment of twigs containing this borer in various stages of growth, with the information that it was more abundant than last year, notwithstanding his care at the time to cut

and burn all twigs observed to be infested. As his orchards are very extensive it is not surprising that a sufficient number of beetles escaped last autumn to more than keep up the succession.

I have not been able to ascertain whether any account of the habits of this species accompanied the original descriptions, but as the orchards from which it was reported to me are located in the Ozark Mountains, so called, it probably migrated from some tree or shrub indigenous to the forests of that region. It is undoubtedly annual brooded and there is occasion to fear that it will become a more pernicious pest than its congeners, *E. villosum* or *Oncideres cingulatus.* The only remedy seems to be persistent pruning of the twigs betraying its presence. It is possible that spraying the foliage with Paris green during the month of May would tend to keep the beetle from the trees, but the experiment has not yet been made.

NOTES ON REMEDIES.

Cotton Bands for Canker-worms.—Having found the sticky bandages—tar, molasses, etc.—for the female Canker-worm moth rather troublesome by reason of the necessity for frequent renewal, I resolved last spring to ascertain the value of the loose cotton bands for the same purpose. I accordingly procured three or four "batts" of the cheapest quality of cotton wool. These were opened as carefully as possible and divided into strips about 4 inches wide and long enough to encircle the trees, which varied from 2 to 3 feet in circumference. The cotton was first temporarily fastened by a couple of tacks, or by the double tacks used in putting down India matting. Afterwards, to make the bandages more secure, a cord string was tied around it in the middle. Three batts of the cotton, costing 36 cents, were found sufficient to furnish a girdle for forty trees. Notwithstanding that these bandages were applied rather late—March 17—a large number of the female moths were trapped. Most of these would be dead when examined, having exhausted themselves in vain efforts to free their legs from the entangling fibers. Numerous clusters of eggs would also be found. The trees were examined every two or three days and eggs and living moths crushed. The cotton proved such an effective barrier that I do not think a single female succeeded in passing it, the very few worms that appeared later on the foliage being in all probability the progeny of moths that had ascended the tree previous to the application of the bands. Several wind and rain storms occurred during the latter part of March and early in April, without greatly impairing the necessary fluffiness of the cotton. All things considered, I think this the cheapest and best of the Canker-worm moth-traps. To be perfectly effective, the cotton should be attached as early as the 1st of March, or even in February, if the season is an early one.

Bran or Mill-feed for Cabbage-worms.—An acquaintance who is very succesful in growing vegetables claims to have found in the products above-named a remedy for *Pieris rapæ.* He dusts his plants thickly while the dew is on with one or the other of these innocuous substances and in this way preserved his cabbages from destruction. He considers the action of this remedy merely mechanical, preventing the larvæ from obtaining a foothold, so to speak, and says that he has repeatedly observed them drop off when attempting to crawl over the thickly-dusted leaves.

Arsenical Solutions.—My experience with alkaline solutions of arsenic was not during the past summer entirely satisfactory. As *aqua ammonia* in small quantities is known to be a valuable stimulant to plant growth I conceived the idea of using this fluid as a solvent of the arsenic instead of concentrated lye, which had been recommended by some experimenters. I accordingly prepared a solution of 1 ounce of white arsenic in 1 quart of ammonia, and of this I used one table-spoonful to a gallon of water. Tried upon Canker-worms it was effective, but so scorched the tender foliage of the tree on which it was sprayed as to do about as much injury as the worms would have done. Half the quantity of the poison in the water did not suffice to kill the worms. For the rose-slug and leaf-feeding beetles, *Colaspis pretexta* and its allies, it seemed a good remedy but its effects on the foliage were not what I had anticipated. The same remedy was tried on Aphis on Chrysanthemum, but was more injurious to the plants than the insects.

As arsenic is soluble to a certain extent in boiling water I think the use in this way is preferable to any of the alkaline solutions. I do not claim, however, that my experiments this season were conclusive, and propose to repeat them another year on a greater variety of insects.

California Buhach.—This has been considered our best preparation of Pyrethrum powder, but as furnished to and by our local dealers it has this season proved very disappointing. The active principle is so volatile that when the powder is kept in bulk, and opened for the supply of every purchaser, for whom it is put up in paper

packages, the upper layers of the box or barrel are almost worthless and entirely too expensive at 60 or 75 cents per pound. If this product is to retain its popularity and value as an insecticide it must be furnished from the manufactory in air-tight packages in which it will not so speedily deteriorate.

REPORT ON NEBRASKA INSECTS.

By LAWRENCE BRUNER.

LINCOLN, NEBR., *September* 19, 1888.

SIR: Aside from a very limited number of species such as are always more or less injurious, the insect depredations in the State of Nebraska have been unusually few and light during the present year. Among these latter I will notice in brief the following as having attracted my attention at the time of their occurrence:

Plum weevils (*Conotrachelus nenuphar* and *Coccotorus scutellaris*), the Codling Moth (*Carpocapsa pomonella*), Cabbage butterflies (*Pieris protodice* and *P. rapæ*), the Army-worm (*Leucania unipuncta*), the Large Willow Saw-fly (*Cimbex americana*), the Box-elder Aphid (*Chaitophorus negundinis*), the Maple-tree Caterpillar (*Anisota rubicunda*), the Corn-root Worm (*Diabrotica longicornis*), and the Striped Cottonwood-beetle (*Plagiodera scripta*).

PLUM WEEVILS.

On account of late frosts over a large portion of the State, many of the young plums were destroyed, and hence the remaining few suffered greatly from the attacks of Plum weevils. Of these both the "Little Turk" (*Conotrachelus nenuphar*) and the "Plum Gouger" (*Coccotorus scutellaris*) were very conspicuous in their work. In the immediate vicinity of West Point, the locality where I studied these two insects during the year, unfortunately late frosts so nearly destroyed the entire crop of plums, tame as well as wild, that but little could be done in the way of experimenting with arsenical sprays as remedies against their depredations. The little that I was enabled to do with these insects was communicated to you at the time of investigation, hence will not now be repeated.

In connection with the Plum weevils, I wish here again to call your attention to an insect that infests the fruit of the Sand Cherry (*Prunus pumilus*) in a similar manner as does the Plum Gouger the fruit of the various plums. Specimens of it that I sent on to Washington were determined as *Coccotorus scutellaris* at the time. Is there not a specific difference between the two insects? My impression is that the two are distinct, as the two forms are very constant.

CODLING MOTH.

Wormy apples are more abundant than ever in Nebraska this year—if such a thing be possible—a fact to be greatly deplored. But now that spraying with poisons has been resorted to in many localities, it has proved a successful method of preventing, if not destroying the insects in their earliest stages, we can look for relief. If, however, as I still imagine the case to be, this insect also infests the thorn apples and rose-buds in this region, there will still be trouble from the pest from year to year. Whether or not the latter plants are attacked by this moth, I expect to determine this fall.

Mr. R. N. Day, of Tekamah, Nebr., tells me that trees in his orchard that were treated with a spraying of Paris green are free from the wormy fruit, while those not so treated are infested as usual. He sprayed his trees just as the blossoms began to drop and the fruit to form.

CABBAGE BUTTERFLIES.

While we have not been troubled here in Nebraska to as great an extent this year as last by the larvæ of the Southern and introduced Cabbage butterflies, we have had to contend with them as usual in most localities. I have noticed in particular the almost entire absence of the *P. rapæ* during the spring and summer months of the present year. In conversing with several persons who pay some attention to the collecting of Lepidoptera here in the State, they also spoke of similar observations in connection with this butterfly. Within the last two weeks the flies have become a

little more common. I can only account for their scarcity on the theory of disease and the work of parasites, which both are doing their work recently.

ARMY WORM.

During a recent visit to the northwestern portions of this State and adjoining portions of Dakota and Wyoming, several cases of injury by the "Army-worm" (*Leucania unipuncta*) were brought to my notice. Concerning these I wrote you in my last report for that trip a short time ago.

WILLOW SAW-FLY.

Unless some disease or insect enemy soon appears in sufficient strength to diminish the large Willow Saw-fly (*Cimbex americana*) it will completely destroy our hedges of white willow that grow upon the more elevated prairies. The enemy must necessarily be "natural" for the farmers will not look to the matter themselves. This year again the large slug-like larvæ of this insect appeared in even greater numbers than on previous occasions, and over much more extended areas. In some instances the Wild Willows also suffered when growing isolated and upon rather high ground. Several farmers followed my instructions and cleared away the débris along their hedges last fall, and burned it, and in that way destroyed the pupæ. Where these were isolated from other infested hedges the remedy was quite apparent, but where other pupæ were close at hand the work done made no perceptible diminution in the number of larvæ present.

COTTONWOOD LEAF-BEETLE.

The "Cottonwood Leaf-beetle" (*Plagiodera scripta*) was again present in injurious numbers in some localities this summer. The damage caused by it was much less noticeable than during previous years owing to the greater rain-fall and consequent more luxuriant growth of the tree infested. In our frontier counties where "tree claims" form a large per cent. of the cultivated area, and the timber growth is limited and small, this insect has been more or less destructive to the young trees planted. In some instances an entire replacement of trees twice over was necessitated.

BOX-ELDER PLANT-LOUSE.

During early June and up to the 20th of the month the Box-elder trees growing along the streets and in other localities, over a considerable portion of eastern Nebraska, were much infested with large numbers of *Chaitophorus negundinis*. In some instances the trees were so completely covered by them as to almost entirely occupy the green portions. A little later, the natural enemies succeeded in gaining mastery over them, so that now (September 15) but few remain and the trees have regained their usual healthy appearance. This louse is preyed upon by the same enemies that usually attack above-ground-feeding Aphids. They are Coccinellids, Lace-wings, and Syrphids.

MAPLE-TREE CATERPILLARS.

The soft maples of Lincoln, Nebr., were attacked by myriads of the larvæ of *Anisota rubicunda* during the month of August. At present there are many trees that are completely stripped of all semblance of leaves—the mid-ribs alone remaining—in some cases. Box-elders also have been attacked to a very limited degree by the same insect. In connection with the distribution of these larvæ over the city, I noticed that the outside electric lights appear to act as a prime factor. On the capitol grounds, comprising four blocks, where there are two strong arc lights, one at each end, but few worms occur. Beyond, about a block in a circular form, the trees are stripped for a radius of about two blocks more, and still further beyond the numbers diminish as the distance increases. In the country beyond the worms are met with only occasionally. The side away from the light of the business part of the city is most infested.

Feeding in company with the above there are quite a number of other larvæ of different species, but chiefly Acronyctas and Geometrids. The cottonwood and ash trees also have their quota of caterpillar enemies here in the city this year, but in much fewer numbers than those feeding on the maples. All of them appear to have been drawn to the city from the surounding country by the electric lights.

CORN-ROOT WORM.

The larva of *Diabrotica longicornis* has been present as a pest in several of the counties of eastern Nebraska and western Iowa during the summer. Early in August its presence was observed at different localities, and specimens forwarded to you at Washington, by correspondents other than myself—I being away from home at the time, and the insect not present in injurious numbers in the vicinity of West Point. Some few instances of a total destruction of an acre or two of corn by its ravages are the extent of the depredations caused by this insect.

Taking the summer as a whole, when compared with other years, insect depredations were rather light, and the depredators comparatively few. The Chinch Bug only appeared in a very few localities in sufficient numbers to damage small grain, and later in the season were prevented by the copious rains from injuring the corn crop. Cut-worms, it is true, troubled some in spring, especially upon sandy soil, but not more than ordinarily, taking the State over.

Locusts were only present in injurious numbers at one or two points, and these were confined to the "native" species. In the city of Lincoln and adjoining, the large yellow locust (*Melanoplus differentialis*) did a little damage to flowers, trees, shrubs, and garden truck.

Having reported the various insect injuries that came to my notice from time to time as they occurred, I do not think it necessary to repeat the same here. Suffice it to state that we do not apprehend any great damage next year from any particular species that affects crops.

Very truly, yours,

LAWRENCE BRUNER.

Prof. C. V. RILEY,
U. S. Entomologist, Washington, D. C.

EXPERIMENTS ON THE BOLL WORM INJURING TOMATOES.

By S. M. TRACY, *Temporary Agent.*

LETTER OF SUBMITTAL.

AGRICULTURAL COLLEGE, MISS., *September* 18, 1888.

SIR: I have the honor to make the following report of an attempt made under your instructions to devise some practical method for the destruction of the Tomato Worm (*Heliothis armigera*).

S. M. TRACY.

Prof. C. V. RILEY,
United States Entomologist.

On May 21 I was informed that the worms had made their appearance in considerable numbers at Crystal Springs, Miss., and I at once proceeded to that point to commence operations in testing the efficiency of different insecticides. Mr. N. L. Fulgham placed at my disposal a large field of plants on which the worms were abundant.

Tests were made with Paris green, London purple, peroxide of silicates, pyrethrum, and kerosene.

All excepting the kerosene were dusted over the plants at the rate of one pound per acre, using a Woodason bellows, so that the powder could be made to reach the under side of the leaves, and special care was taken that the unripe fruit should receive a fair share of the application. Paris green and London purple were also applied suspended in water, at the rates of 40, 50, and 60 gallons of water to 1 pound of the poison, a No. 3 Nixon nozzle being attached to the force-pump used for their distribution. Two forms of kerosene emulsion were used, one being the ordinary form made by churning together four pounds of soap, one gallon of water, and two gallons of kerosene; the other was made in the same manner excepting that one-half pint of spirits of turpentine was added to the mixture before churning. The latter mixture gave an emulsion with much less labor, and one which was entirely stable. These emulsions were each diluted with twenty-five, forty, fifty, and sixty parts of water to one of the emulsion. The emulsions were all applied with a force-pump having a No. 2 Nixon nozzle. A sufficient amount of

the emulsion was applied to thoroughly moisten the leaves. Applications of all the preparations were made upon two blocks, in one of which the fruit was just beginning to ripen, while on the other a few of the fruits were nearly full grown, but the majority were small. In all cases a block of untreated plants was left on each side of the treated blocks, so that the effects of the treatment might be more readily observed. Each block contained about one hundred plants, and all applications were made in duplicate upon widely separated blocks. The results were as follows:

Peroxide of Silicates.—No effect.

Paris Green, dry, and in suspension in 40 and in 50 gallons of water to 1 pound of poison, apparently killed fully one-half the young worms, but a large number escaped. The mixture in 60 gallons of water accomplished but little.

London Purple in suspension produced somewhat more marked effects than did the Paris green, but was less effective when applied dry.

Kerosene Emulsions.—These were much more effective than were any others of the applications made. When the emulsions were diluted with twenty-five, forty, and fifty parts of water, nearly every worm and egg on the treated plants was destroyed; when sixty parts of water were used, a few, perhaps one-fourth, escaped. When twenty-five parts of water were used in the emulsion without turpentine a few of the very young leaves were injured, but the damage was so slight as to be scarcely appreciable. For several days after making the applications the weather was cloudy, so that applications which might otherwise have scalded the leaves were harmless.

Pyrethrum produced no effect except to kill the few worms with which it came in contact very soon after its application.

From the fact that the worm enters the fruit very soon after hatching it is impossible to ascertain the exact proportion which was killed, and the estimates given above were based on the numbers of young worms found in the fruits after the applications had been made, as compared with the numbers found in adjoining untreated blocks.

Trapping the moths by means of lights placed in dishes of sweetened water was attempted, but with the usual result that only males and a few aged females were taken.

About June 1 the worms made their appearance about Starkville, and the work was continued there. This was practically a repetition of that already done at Crystal Springs, and the results were so nearly the same that the details need not be given.

Fruit was taken from plants which had been sprayed with Paris green one week after spraying, and a careful chemical analysis of the water in which it was washed showed no trace of either arsenic or copper.

During the entire time the worms were found on the tomatoes the weather was very rainy, and so made the work unsatisfactory, and in some cases it was impossible to say whether the worms had been killed by the applications or were washed off by the rain. As a result of the work as a whole, I feel quite sure that thorough applications of Paris green will be found effective, and that these applications will have no injurious effect upon the fruit. From kerosene emulsions, diluted to one part in forty and used thoroughly and persistently, still better results will be had, but the applications must be made as often as once a week. The first application may be made very easily and quickly just before the plants are taken from the cold-frame.

EXPLANATION TO PLATES TO REPORT OF ENTOMOLOGIST.

Where figures are enlarged the natural sizes are indicated in hair-lines at side, unless already indicated in some other way on the plate.

EXPLANATION TO PLATE I.

THE PLUM CURCULIO.

(Original.)

FIG. 1.—Full-grown larva—greatly enlarged.
FIG. 2.—Pupa, ventral view—greatly enlarged.
FIG. 3.—Same, dorsal view—greatly enlarged.
FIG. 4.—Adult, from side—greatly enlarged.
FIG. 5.—Adult, dorsal view—greatly enlarged.
FIG. 6.—Adults on plum twig in spring, eating—natural size.
FIG. 7.—Cherries, showing work of larva—natural size.
FIG. 8.—Young plums, showing crescent mark made in oviposition, and also irregular holes made by the adults while feeding—natural size.

EXPLANATION TO PLATE II.

THE HOP PLANT-LOUSE.

(Original.)

FIG. 1.—Plum twig, showing winter eggs—natural size.
FIG. 2.—First generation on plum, or "stem-mother"—greatly enlarged.
FIG. 2*a*.—Portion of head and base of antenna of same—still more enlarged.
FIG. 3.—Second parthenogenetic female generation—greatly enlarged.
FIG. 3*a*.—Head and base of antennæ of same—still more enlarged.
FIG. 4.—Third generation, "winged migrant," the "Pseudogyne"—greatly enlarged.
FIG. 4*a*.—The same, head and base of antennæ—still more enlarged.
FIG. 5.—The same, side view—greatly enlarged.
FIG. 6.—The same, pupa—greatly enlarged.
FIG. 6*a*.—Head and base of antennæ of pupa—still more enlarged.

EXPLANATION TO PLATE III.

THE HOP PLANT-LOUSE.

(Original.)

FIG. 1.—Hop leaf with lice as they appear naturally—natural size.
FIG. 2.—Fourth generation, the first on hop, shown in the act of crawling—greatly enlarged.
FIG. 2*a*.—Base of antennæ of same—still more enlarged.
FIG. 3.—Same, with antennæ thrown back as in rest—greatly enlarged.
FIG. 4.—Winged return migrant or pupifera, with wings expanded—greatly enlarged.
FIG. 4*a*.—Head and base of antennæ of same—still more enlarged.
FIG. 5.—Pupa of "return migrant"—greatly enlarged.
FIG. 5*a*.—Head and base of antennæ of same—still more enlarged.

EXPLANATION TO PLATE IV.

THE HOP PLANT-LOUSE.

(Original.)

FIG. 1.—Sixth generation, normal parthenogenetic female—greatly enlarged.
FIG. 1*a*.—Head and base of antennæ of same—still more enlarged.
FIG. 2.—Winged male, with wings expanded—greatly enlarged.
FIG. 3.—Pupa of same—greatly enlarged.
FIG. 4.—Gravid sexual female, showing eggs through skin—greatly enlarged.
FIG. 5.—Young sexual female—greatly enlarged.
FIG. 6.—Shrunken female in act of ovipositing, showing winter eggs when fresh laid—greatly enlarged.

EXPLANATION TO PLATE V.

SILK-CULTURE APPARATUS.

(Original.)

FIG. 1.—Apparatus for washing silk-worm eggs—greatly reduced.
FIG. 2.—Apparatus for conditioning cocoons—reduced.

EXPLANATION TO PLATE VI.

SILK-CULTURE APPARATUS.

(Original, except Fig. 2.)

FIG. 1.—Caliper for measuring cocoons—reduced.
FIG. 2.—The blanc cocoon volumeter—reduced (from third report Lyons Silk Laboratory).
FIG. 3.—Electric stop-method for testing reel.

EXPLANATION TO PLATE VII.

(Engraved from photograph.)

Apparatus for spraying hop yards.

EXPLANATION TO PLATE VIII.

(Engraved from photograph.)

Tent for propagating imported parasites.

EXPLANATION TO PLATE IX.

ENEMIES OF ICERYA.

(Original.)

FIG. 1.—*Entedon coquillettii:* *a*, antennæ; *b*, mouth parts; *c*, fore leg; *d*, middle leg; *e*, hind leg; *f*, wings; *g*, submarginal vein of fore wing; *l*, abdomen—all greatly enlarged.

FIG. 2.—*Euryischia lestophoni*—greatly enlarged.

FIG. 3.—*Thoron opacus:* *a*, antennæ; *b*, fore leg; *c*, middle leg; *d*, hind leg; *e*, part of fore leg; *f*, abdomen; *g*, wings; *h*, hooks of hind wings—all greatly enlarged.

EXPLANATION TO PLATE X.

ENEMIES OF ICERYA.

FIG. 1.—*Encyrtus dubius*—enlarged (original).

FIG. 2.—*Piesma cinerea*—enlarged (after Riley).

FIG. 3.—*Coccophagus californicus* — enlarged (original).

FIG. 4.—*Piezostethus californicus* — enlarged (original).

FIG. 5.—*Lyctocoris campestris*—enlarged (original).

FIG. 6.—*Eremocoris tropicus*—enlarged (original).

FIG. 7.—Australian Lady-bird—enlarged (original).

FIG. 8.—*Rodolia iceryæ*—enlarged (original).

EXPLANATION TO PLATE XI.

FIG. 1.—*Chilocorus cacti:* *a*, larva; *b*, pupa; *c*, adult—enlarged (after Comstock).

FIG. 2.—*Lestophonus iceryæ* — enlarged (original).

FIG. 3.—*Alaptus iceryæ*—enlarged (original).

FIG. 4.—Hook used in boiling off cocoons (original).

EXPLANATION TO PLATE XII.

NATURAL ENEMIES OF THE PLUM CURCULIO.

(Figures all after Riley.)

FIG. 1.—*Chrysopa plorabunda:* *a*, eggs; *b*, larva; *c*, cocoon; *d*, adult—all enlarged.

FIG. 2.—*Chauliognathus pennsylvanicus:* *a*, larva, full-grown—natural size; *b*, *c*, *d*, *e*, *f*, *g*, *h*, head parts—enlarged; *i*, adult beetle—natural size.

FIG. 3.—*Harpalus pennsylvanicus:* *a*, anterior tarsus and part of tibia showing notch—enlarged; *b*, beetle—slightly enlarged.

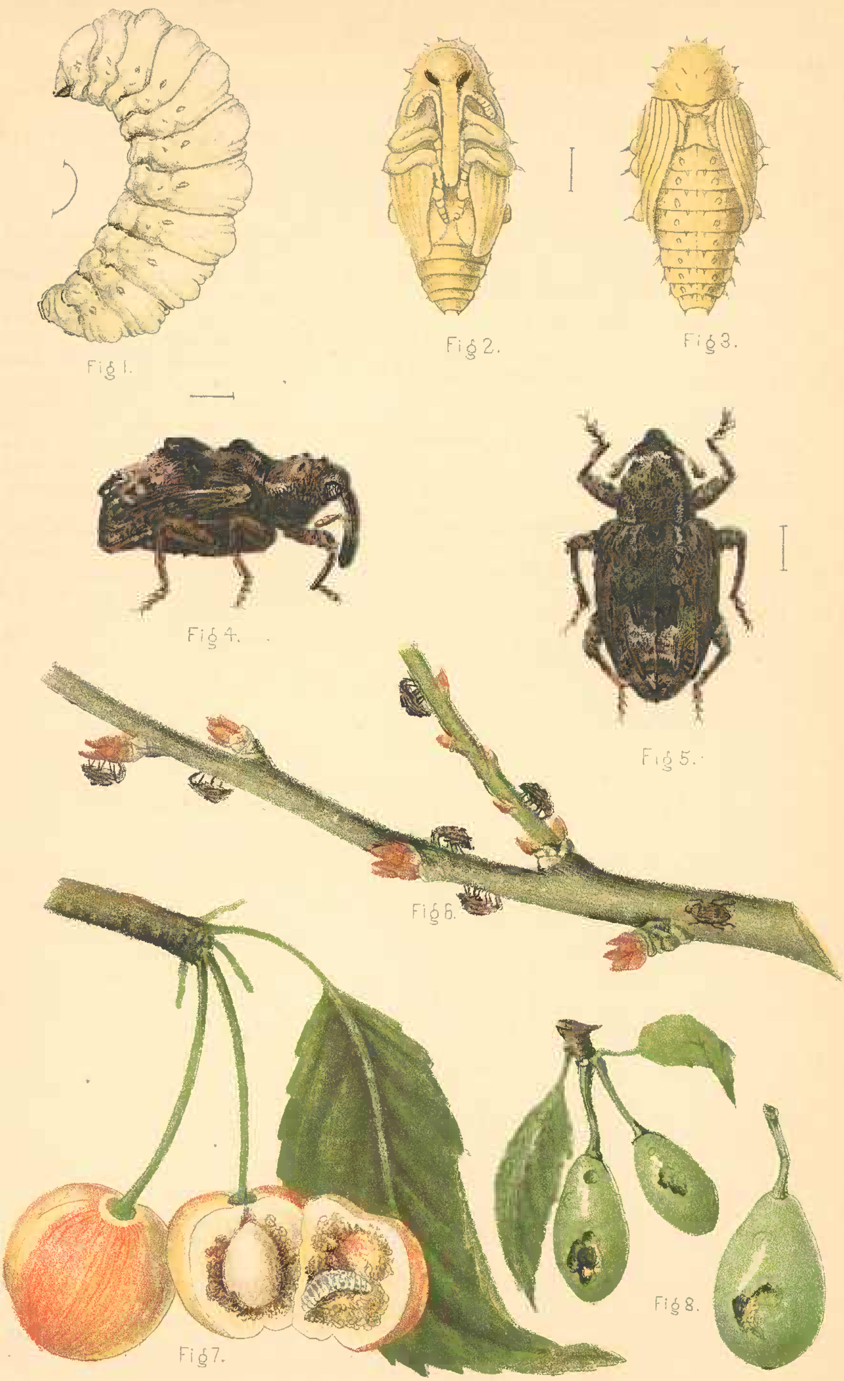
FIG. 4.—*Harpalus* sp. (*pennsylvanicus ?*): *A*, larva—natural size; *B*, under side of head showing parts at *c*, *e*, *f*, *g*—enlarged; *h*, *i*, *j*, under side of different joints of body—natural size.

FIG. 5.—*Aspidoglossa subangulata*—enlarged.

FIG. 6.—*Thersilochus conotracheli:* *a*, female; *b*, male; *c*, antenna—all enlarged.

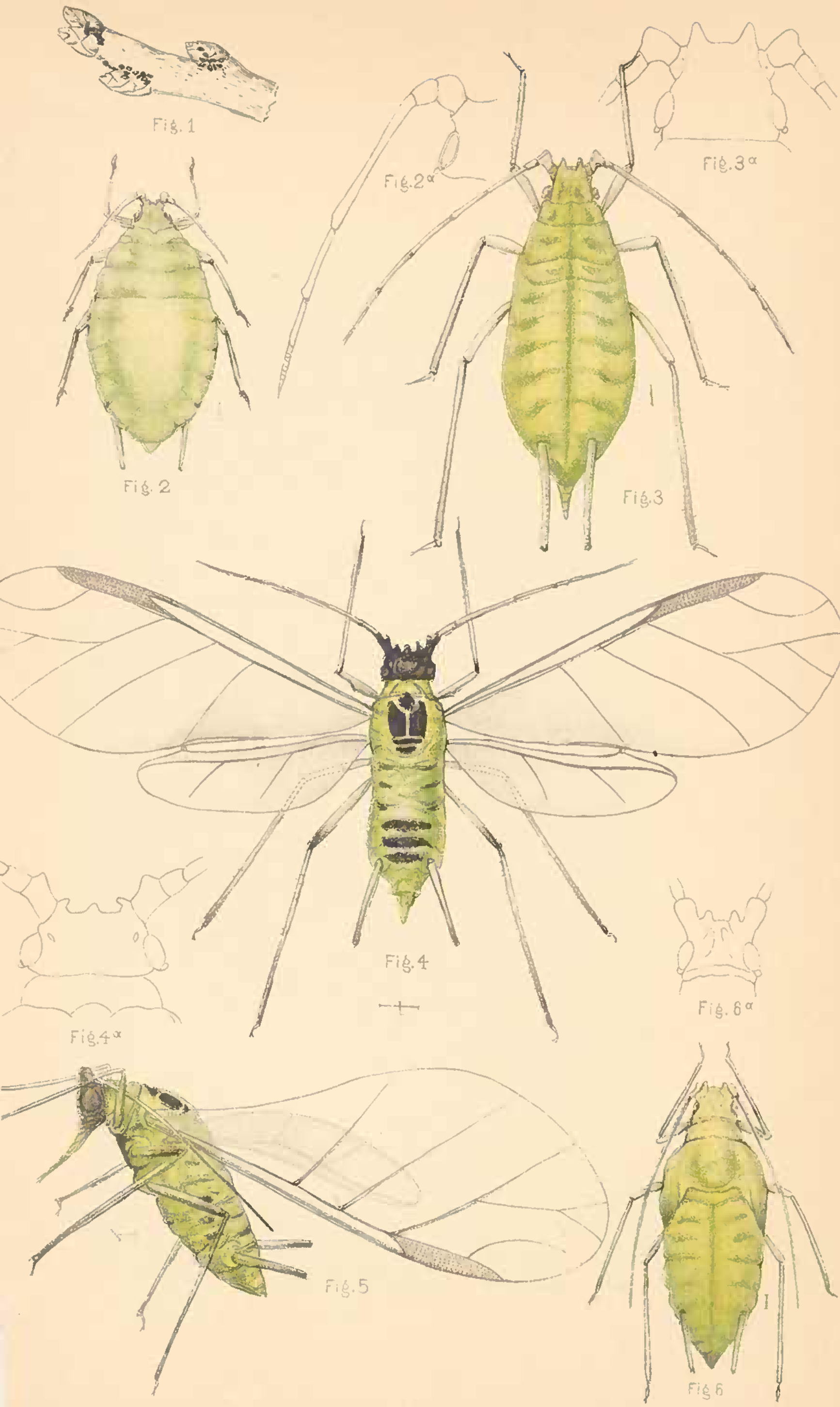
FIG. 7.—*Sigalphus curculionis:* *a*, male; *b*, female; *c*, antenna—all enlarged.

FIG. 8.—*Sigalphus curculionis:* *a*, larva; *b*, silken cocoon; *c*, pupa—all enlarged.

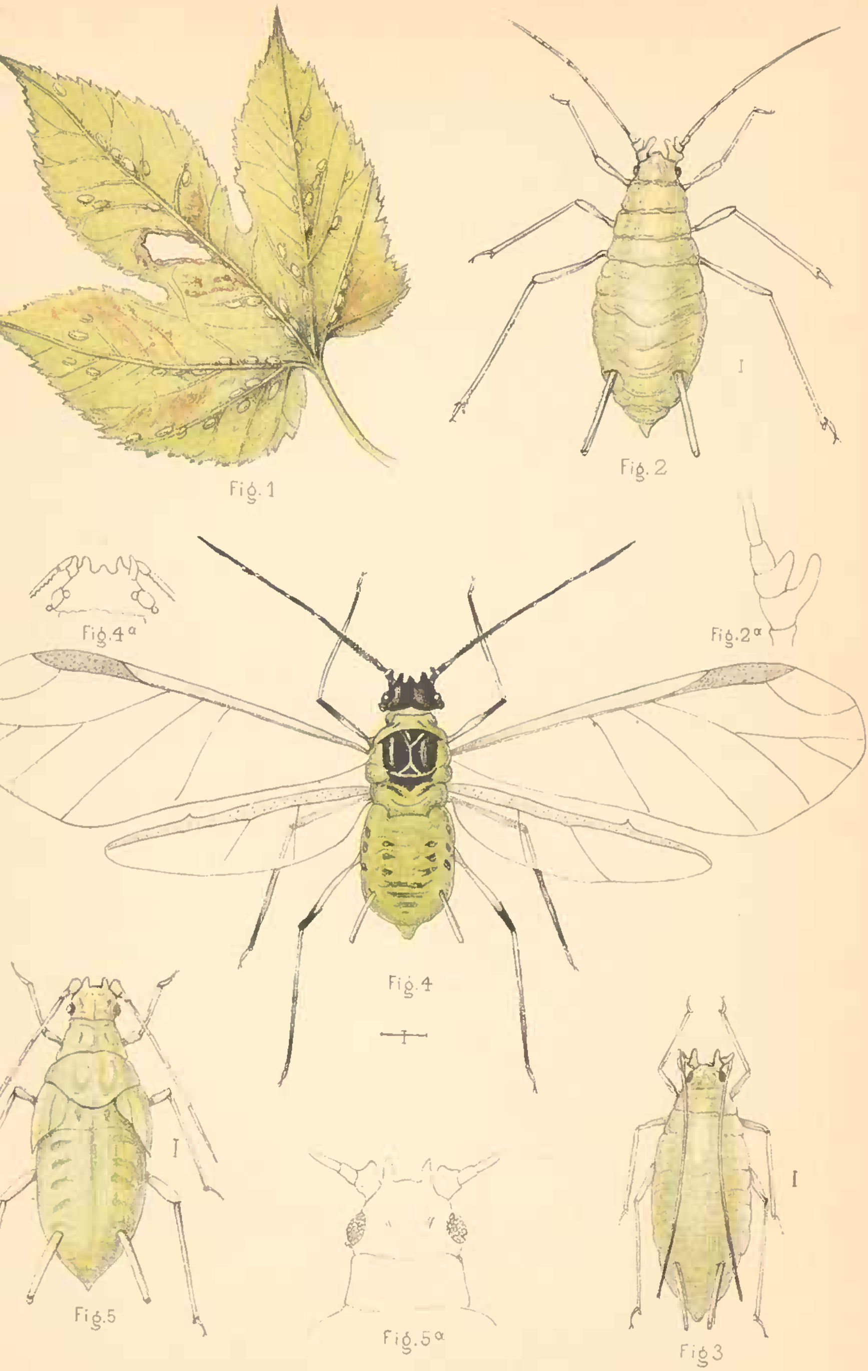


GILES LITHO & LIBERTY PRINTING CO. N.Y.

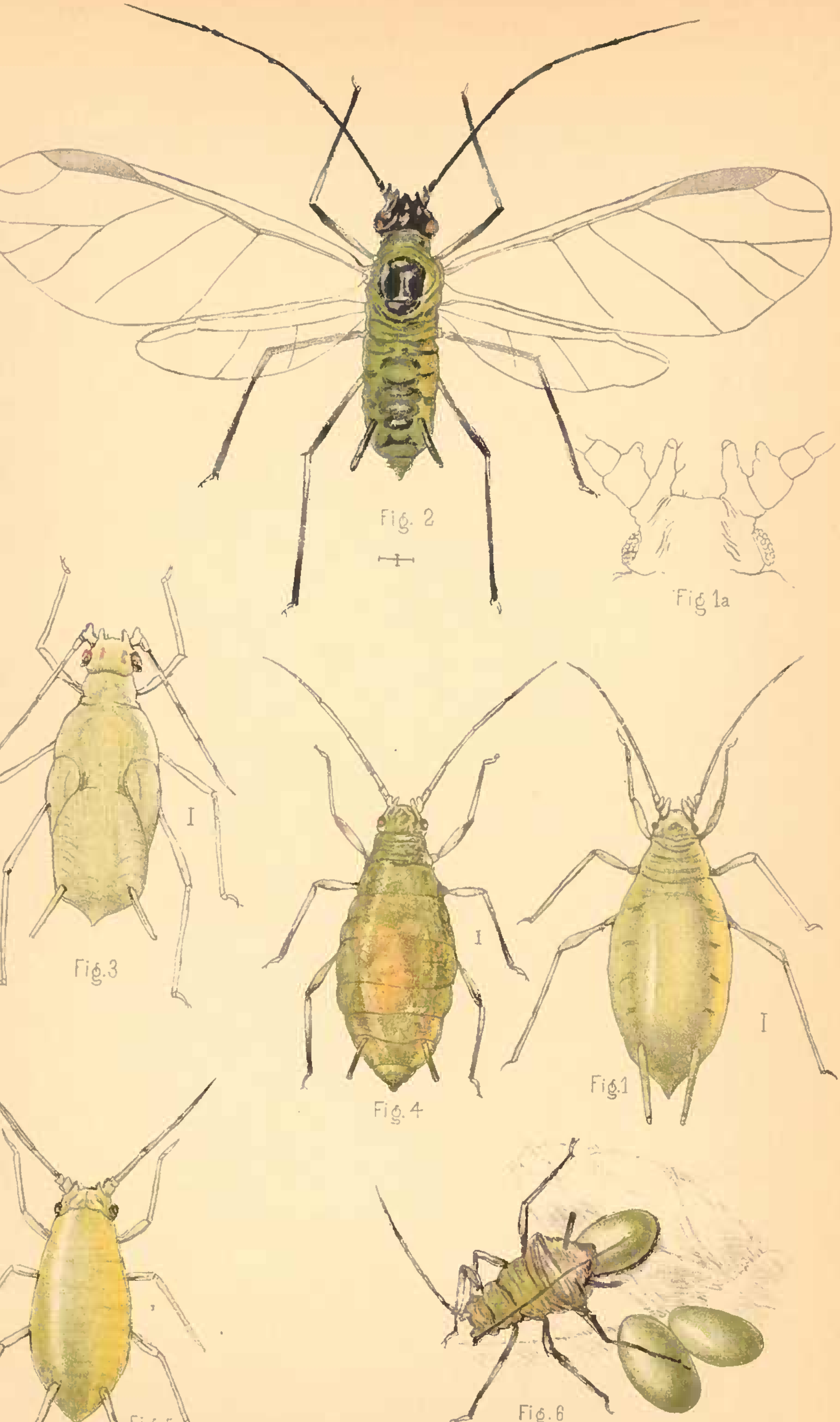
THE PLUM CURCULIO.



THE HOP PLANT-LOUSE.



THE HOP PLANT-LOUSE



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THE HOP PLANT-LOUSE.

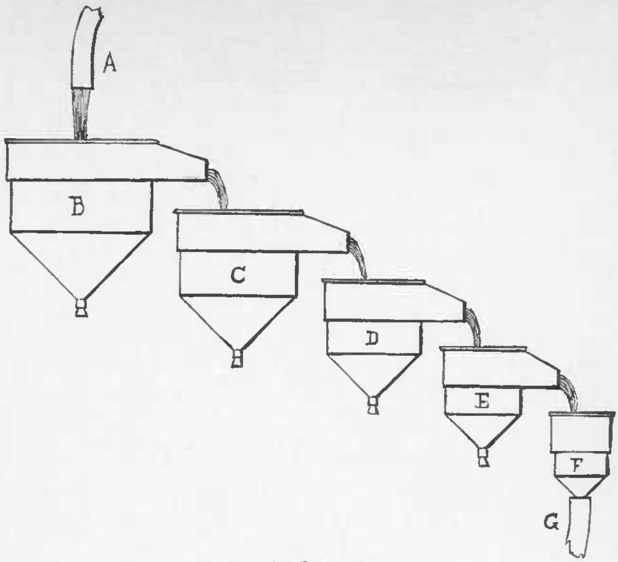


Fig. 1.—Egg-washer.

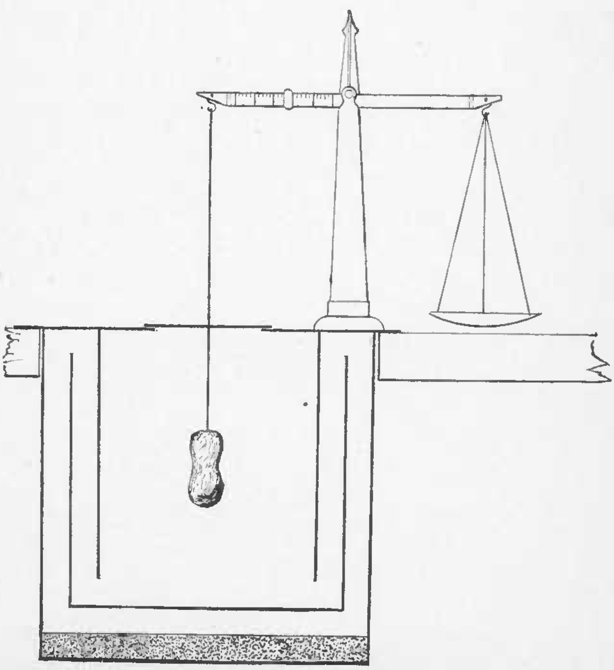


Fig. 2.—Conditioning Apparatus.

SILK CULTURE APPARATUS.

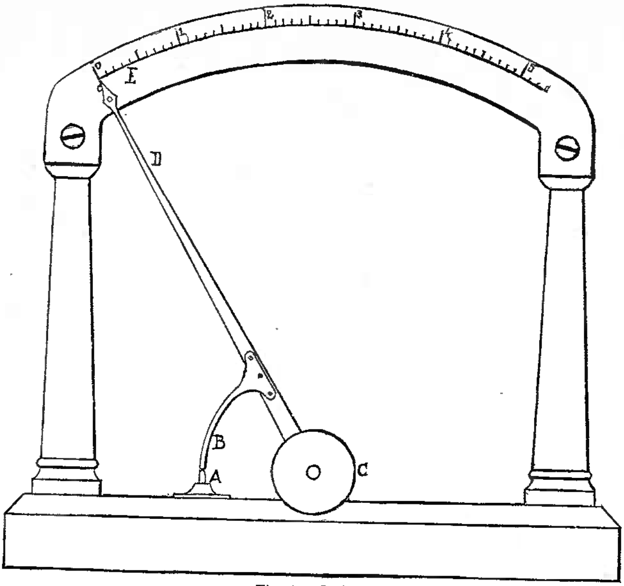


Fig. 1.—Caliper.

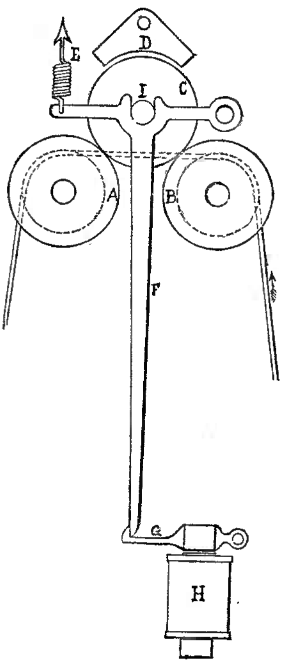


Fig. 3.—Stop Motion.

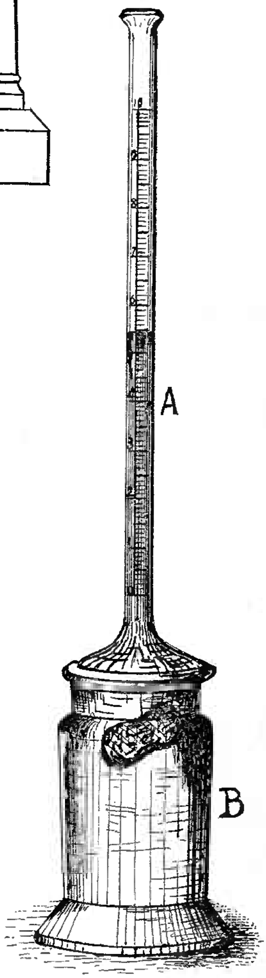


Fig. 2.—Volumeter.

SILK CULTURE APPARATUS.

Report of the Entomologist, U. S. Department of Agriculture, 1888.

TENT FOR PROPAGATING IMPORTED PARASITES.

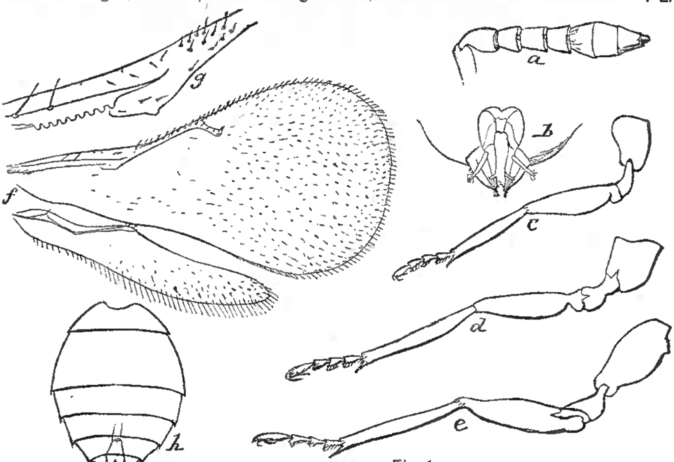


Fig. 1.

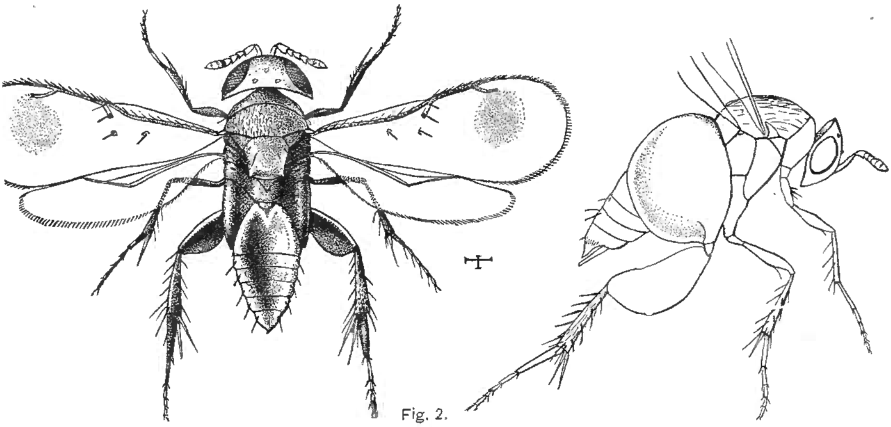


Fig. 2.

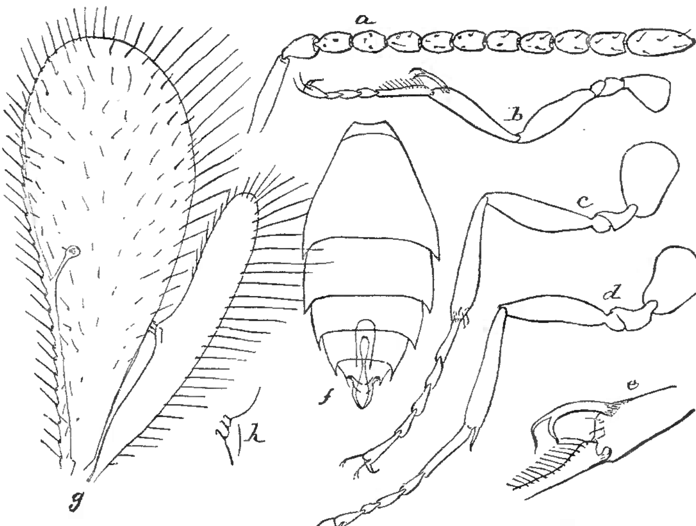


Fig. 3.

ENEMIES OF ICERYA.

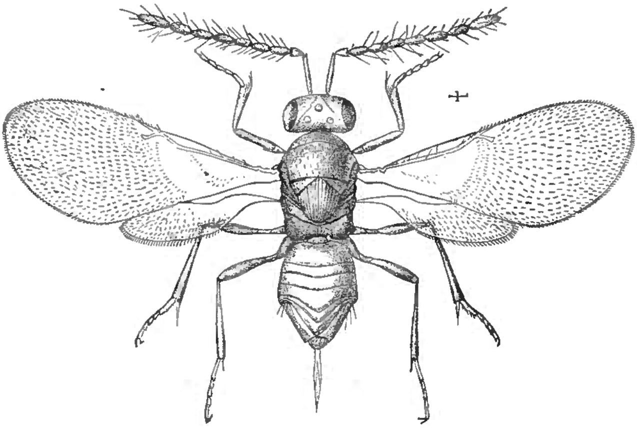


Fig. 1.

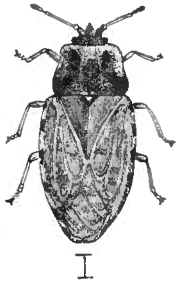


Fig. 2.

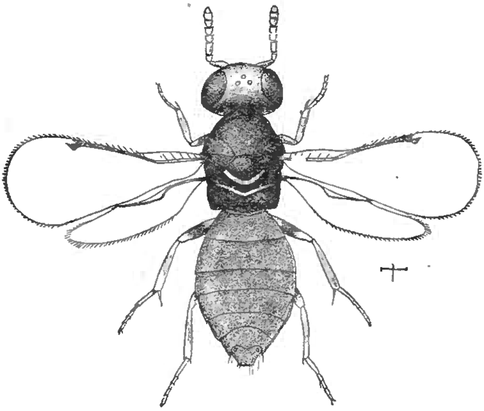


Fig. 3.

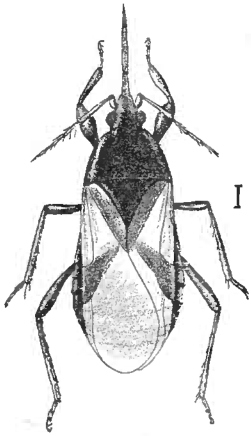


Fig. 4.

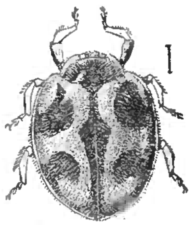


Fig. 7.

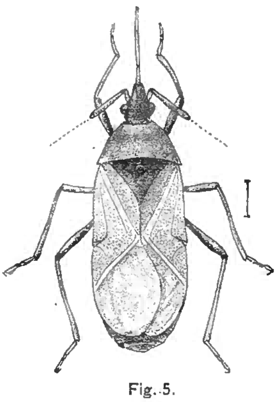


Fig. 5.

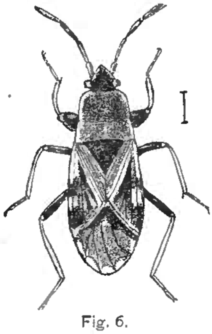


Fig. 6.

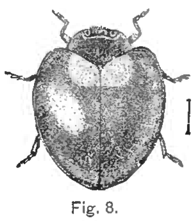


Fig. 8.

ENEMIES OF ICERYA.

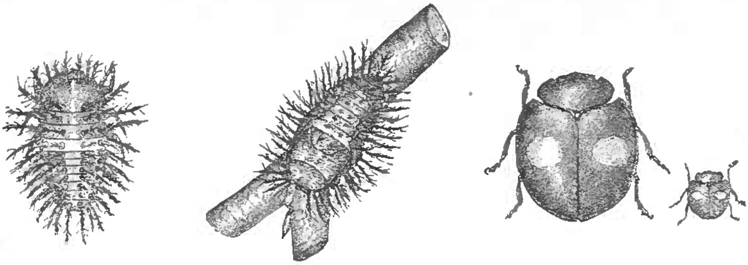
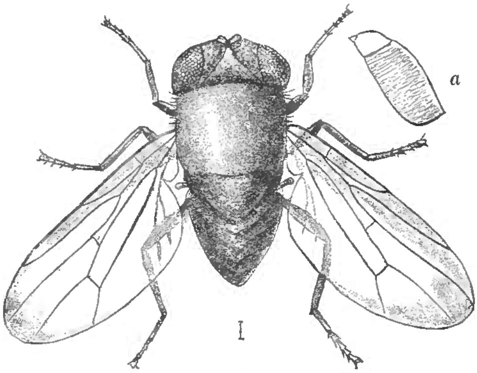


Fig. 1.



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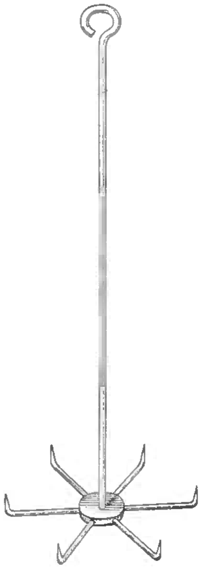

Fig. 4.

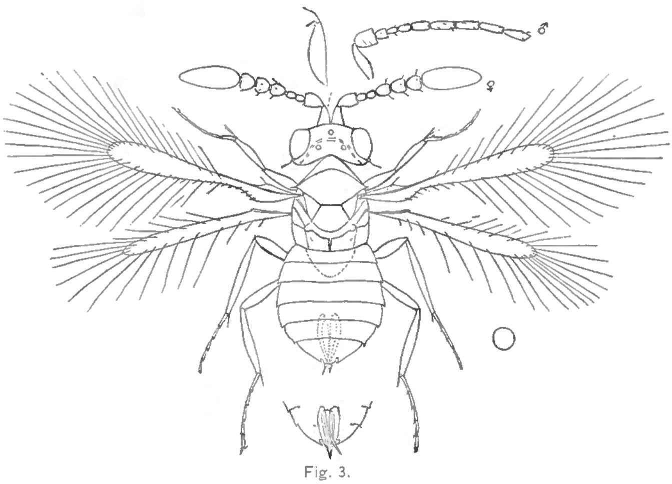

Fig. 3.

ENEMIES OF ICERYA.

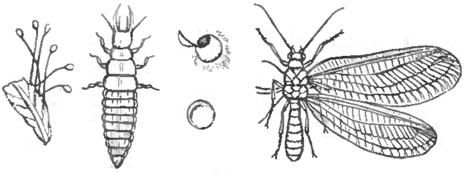

Fig. 1.

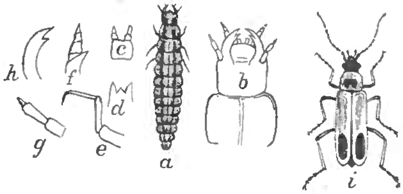

Fig 2.

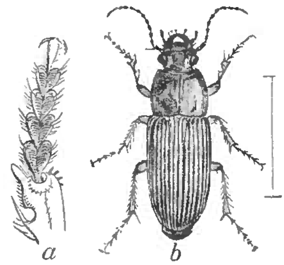

Fig. 3.

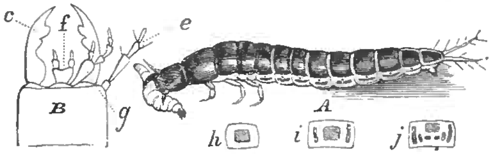

Fig. 4.

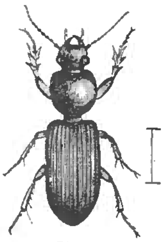

Fig. 5.

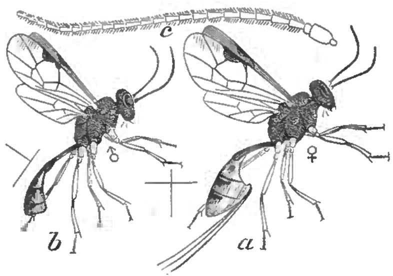

Fig. 6.

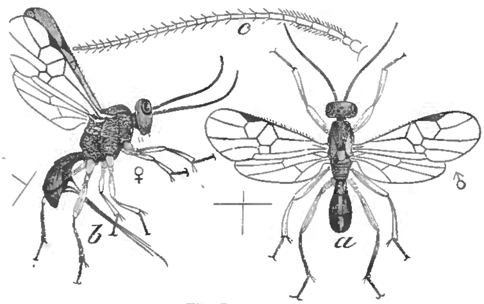

Fig. 7.

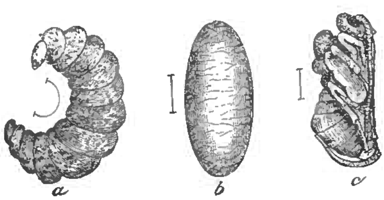

Fig. 8.

NATURAL ENEMIES OF THE PLUM CURCULIO.

REPORT OF THE CHIEF OF THE BUREAU OF ANIMAL INDUSTRY.

SIR: I have the honor to transmit herewith my report, which contains a statement of the more important work accomplished by the Bureau of Animal Industry during the year 1888. For many interesting details of this work accomplished during the year I must refer you to the Fourth Annual Report of the Bureau of Animal Industry.

Very respectfully,

D. E. SALMON,
Chief of the Bureau of Animal Industry.

Hon. NORMAN J. COLMAN,
Commissioner of Agriculture.

OPERATIONS OF THE BUREAU.

The year 1888 has been one of great activity in all branches of the work of this Bureau. A strict quarantine has been maintained in all the districts affected with pleuro-pneumonia; diseased and exposed animals have been promptly slaughtered, and contaminated premises have been disinfected. Investigations have been made of many outbreaks of disease among all the species of domesticated animals, and particular attention has been given to the scientific study of such epizootic diseases as hog cholera, swine plague, glanders, southern cattle fever, tuberculosis, and various maladies caused by animal parasites. In addition to this an inquiry has been commenced in regard to the number and value of thorough-bred animals, the characters of the different breeds and their grades, and the degree in which they answer the market requirements of the present day; also in regard to the condition and means of improving special industries, sheep husbandry having been selected for first consideration, to be followed by horse-breeding, dairying, hog-raising, etc.

PLEURO-PNEUMONIA.

The chief work of this Bureau for the year has been the continued effort to secure the eradication of the contagious pleuro-pneumonia or lung plague of cattle. Since my last report was made the operations have been extended to all the infected districts, and as the new territory covered embraces those sections of Long Island where the disease has longest existed, where large numbers of cattle are kept, and where, consequently, the contagion was most thoroughly disseminated, the work done and the expenditures required have been correspondingly heavy.

The progress made during the year has been very encouraging. No cases of pleuro-pneumonia have been found west of the Alleghany Mountains since the date of my last report. A supervision of the infected district in Cook County, Ill., was maintained until April 1, 1888, and as no further cases of the plague developed, all quarantine restrictions were then removed. Investigations have been made of all outbreaks of cattle disease in the Western States which were reported to the Department with any of the characteristics of lung plague, and it is gratifying to be able to state that in no case has this disease been found in that section.

Much apprehension was expressed a year ago by those interested in this subject in regard to the danger of the plague spreading from the State of Pennsylvania. The Department had not been able to reach any satisfactory terms of co-operation with the State authorities, and exaggerated rumors of the existence of lung plague there were almost continually in circulation. Repeated efforts were made to secure co-operation, and I am glad to be able to state that these were finally successful. The only district in Pennsylvania where there was good reason to suspect the existence of pleuro-pneumonia was in the city of Philadelphia and its suburbs. All that district embraced within a radius of 8 miles from the city hall was placed in quarantine by a proclamation of the governor; the cattle were inspected; a numbered tag was placed in the ear of each one; all animals were recorded upon the books of the Bureau; none were allowed to be moved upon the highways without a permit; all incoming animals were inspected, and, in general, all the regulations were enforced which have been found necessary to secure the eradication of this malady in other places. The quarantine there will be discontinued on December 15, by order of the governor, but veterinary supervision will be maintained. Some herds were found in the Philadelphia district affected with pleuro-pneumonia, though not as many as was anticipated. The details of this work will be found below.

While no new outbreaks of the disease have been discovered outside of the known infected States, with the single exception of one in Virginia, a few have been found in previously uninfected regions within those States. By far the most serious of these is one recently discovered and now in progress in Orange County, N. Y. It seems probable that the plague had existed there for more than a year and had been concealed by interested parties. It will probably not be very difficult to exterminate the contagion from that section, though this expense was not anticipated and will be quite heavy. Already the number of diseased and exposed animals found is between 400 and 500, and it will doubtless be considerably increased. An effort is being made to trace the introduction of the contagion, and to learn by what means it occurred. It seems probable, however, that the affected animals were taken there before the numbering and registering of the cattle in the old infected districts was accomplished.

New infections are becoming less numerous as the disease is less prevalent in the infected centers, and there is good reason to believe that if the quarantine restrictions can be maintained a sufficient time they will cease entirely. Unfortunately, as the contagion becomes less prevalent, the necessity for these restrictions is not so apparent, and there is a more general disposition on the part of the people to disregard them, a disposition which is encouraged by the failure of local authorities to vigorously prosecute and convict offenders.

THE WORK IN NEW YORK.

At the time the last report on this subject was submitted a force was being organized to inspect, tag, and register all the cattle and maintain quarantine restrictions in the old infected district of New York, that is, in the counties of Westchester, New York, Richmond, Kings, and Queens. The task was one of great magnitude and has been beset with many unexpected difficulties. In the first test case that came before the courts the governor's proclamation was decided to be invalid, because he had not designated the infected district, but had left it to the Chief of the Bureau of Animal Industry to designate and advertise such districts as might be discovered. The court held that the governor could not delegate this authority.

It was also discovered by the officers of this Bureau that the State law under which the governor's proclamation was issued gave insufficient authority for the necessary regulations, since it did not apply to exposed herds. These facts were laid before the legislature, and, although the session was drawing to a close and it was difficult to obtain action on new subjects, this matter was deemed of such importance that it received favorable consideration, and an amendment was passed which removed the defects in the statutes. Following this, a new proclamation was issued by the governor, and from that time the regulations have been strictly enforced. In some districts it has been necessary to cause many arrests to be made before the people would respect the law, but since they have become convinced that a determined effort is being made to eradicate the disease there has been less occasion for harsh measures.

The progress made in extirpating pleuro-pneumonia from this long-infected district has been very marked. Two of the counties, Westchester and Richmond, have been entirely freed from the contagion. So long a period has elapsed since any cases were discovered in these counties that Governor Hill, on the recommendation of the Chief of the Bureau of Animal Industry, has recently issued an order removing quarantine restrictions.

The complete success of the work over the large territory embraced in these two counties within so short a time is very gratifying, and demonstrates the correctness of the plan adopted.

In the city and county of New York the progress has also been very satisfactory. There are here but a very few herds in which the disease is known to exist, and these are being rapidly disposed of. By far the heaviest work in this county has been done, although it will be necessary, on account of the proportions of the trade and of its being a central market, to keep up a supervision until all parts of the State are free from the contagion.

The disease was found much more prevalent and more generally distributed in Kings and Queens Counties, on Long Island, than elsewhere. Here there has been a continual struggle during the whole year to hold it under control. Much progress has been made and the number of infected herds greatly reduced, but there is still a large amount of work before us.

There has been more disease found during the year than was anticipated at the time the preceding report was written. Partly for this reason, and partly on account of the exhaustion of the appropriation for the year ending June 30, 1888, about six weeks before the end of the year, the results of the year's work have not quite reached our expectations. For nearly two months all active work

ceased and the force was reduced to such an extent that only a mere supervision of the movement of cattle could be maintained. This unfortunate relaxation allowed the plague to develop and has increased the total amount of work to be accomplished to a marked degree. Since we now have the whole infected district in charge, the expenditures can be foreseen with sufficient exactness to prevent such an occurrence happening again, unless there should be new outbreaks of greater dimensions than have been discovered in the past.

A recently discovered outbreak is now in progress in Orange County, which is serious in its extent and will require several months for its complete suppression. Our investigations indicated that the contagion was taken there from the city of New York before the quarantine regulations were established, and it has since been concealed by interested parties. The infected district is now believed to be marked out and under control, and there is no reason to doubt the early success of the measures which have been applied. This outbreak will make an unexpected increase of the expenditures, but probably will not delay the work in the old infected districts of the States.

From January 1 to November 30, 1888, there were inspected in New York 12,333 herds, containing 99,726 head of cattle. Of this number 62,184 were re-examined by deputies in addition to the professional inspections, and 100,370 were tagged with numbers and registered upon the books of the Bureau.

There were 323 new herds found affected with pleuro-pneumonia during the year, and these herds contained 4,647 animals, 691 of which were pronounced diseased when the inspection was made. There were purchased for slaughter during the same time 1,576 affected cattle, at a cost of $40,976.53, an average of $26 per head; also 3,196 exposed cattle at a cost of $72,410.50, an average of $22.65 per head. The smaller cost of the exposed cattle as compared with the affected ones is due to the fact that the amount which the owner realized for the carcasses was deducted from the appraised value, the Department paying the balance.

It has been found necessary to disinfect 1,339 stables, stock-yards, or other premises during the year, and also to make *post-mortem* examinations upon the carcasses of 15,538 bovine animals, of which 2,287 were found diseased with pleuro-pneumonia.

The total expenses in New York from January 1 to November 30, 1888, have been $250,779.47, of which $113,387.03 was paid for cattle purchased for slaughter as either diseased or exposed. The remainder constitutes the expense for disinfection, inspection, tagging, registering, supervising the movement of cattle, *post-mortem* examinations, and all the various expenses incident to a work of this character.

THE WORK IN NEW JERSEY.

In this State the work of the Bureau is not recognized by legislative enactment as clearly as is desirable. There has been constant co-operation with the State Board of Health, through its secretary, Dr. E. M. Hunt, and the inspectors have been given commissions as agents of this board. In this way it has been possible to avail ourselves of the local statutes and to accomplish what otherwise would have been impossible.

At the time my previous report was written a force was being or-

ganized and details of regulations were being perfected for quarantining Hudson County and maintaining complete control of the movement of cattle in that county, and particularly in Jersey City. This county, owing to its proximity to New York, and the fact that its milch cows were to a large degree purchased in the New York market, had long been thoroughly infected.

The enforcement of the regulations in New Jersey, as in other States, has been followed by very gratifying results. There have been a number of outbreaks in the interior, but these in all cases have been promptly suppressed. By far the greater part of the work has been performed in Hudson County, which is now, so far as known, the only infected center.

From January 1 to November 30, 1888, there were inspected in New Jersey 8,018 herds, containing 72,095 head of cattle. Of this number 20,413 were re-examined by deputies, in addition to the professional inspections, and 13,318 were tagged with numbers and registered upon the books of the Bureau.

There were 210 new herds found affected with pleuro-pneumonia during the year, and these herds contained 2,508 animals, 581 of which were pronounced diseased when the inspection was made. There were purchased for slaughter during the same time 502 affected cattle, at a cost of $12,325.50, an average of $24.55 per head; also 945 exposed cattle, at a cost of $25,512.50, an average of $27.10. The higher average cost of exposed cattle in New Jersey as compared with New York is due to the greater difficulty of disposing of the carcasses of such animals, and the smaller amounts which, for that reason, were realized.

It has been found necessary to disinfect 275 stables, stock-yards, and other premises, and also to make *post-mortem* examinations upon the carcasses of 6,846 bovine animals, of which 514 were found diseased with pleuro-pneumonia.

The total expenses in New Jersey, from January 1 to November 30, 1888, have been $85,111.60, of which $37,838 was paid for cattle purchased for slaughter because they were either diseased or had been exposed.

New Jersey is believed to be nearly free from the disease, as but few new herds have been reported during the last sixty days. A large distillery herd is now being slaughtered, and this, with two small diseased herds, constitutes all the infected premises now known in the State. It will, however, be necessary to maintain a force in New Jersey until the plague is eradicated from all parts of New York, or the contagion will be again introduced by the movement of cattle. It is also possible that the disease may be found in the dairies about Newark, but our investigations up to this time have not revealed it.

THE WORK IN PENNSYLVANIA.

The governor of Pennsylvania never formally accepted the rules and regulations prepared in accordance with the act of Congress establishing this Bureau. After much correspondence, however, with the special agent of the governor, who has charge of this branch of the service in that State, an agreement adopting a modification of these rules was decided upon. The chief modification of the rules was that no herd should be slaughtered as affected with pleuro-pneumonia until it had been examined and the diagnosis confirmed by the State veterinarian, who should be paid for this service from the ap-

propriation of the Bureau. It was further agreed that the governor would issue a proclamation placing all cattle in quarantine which were on any premises situated within 8 miles of the city hall of Philadelphia.

The proclamation was issued to take effect upon April 9, 1888, and at that time a force of men employed by the Bureau began work inspecting, tagging, and registering all cattle in the specified district. *Post-mortem* examinations were made on all carcasses of cattle which had died and had been taken to rendering works, and of all cows from this district which were slaughtered for food. With these regulations in force it becomes possible to locate the herds affected with pleuro-pneumonia in the vicinity of Philadelphia, and to eradicate the disease. The relations between the State authorities and the officers of the Bureau have been harmonious, and all differences of opinion in regard to diagnosis have been settled by the slaughter and *post-mortem* examination of the affected animals.

From January 1 to November 30, 1888, there were inspected in Pennsylvania 5,291 herds, containing 72,565 head of cattle. Of this number 18,763 were re-examined by deputies, in addition to the professional inspections, and 51,820 were tagged with numbers and registered upon the books of the Bureau.

There were 23 herds found affected with pleuro-pneumonia, and these herds contained 260 animals, 49 of which were pronounced diseased when the inspections were made. There were purchased for slaughter 63 affected cattle, at a cost of $1,243.50, an average of $19.73 per head; also 131 exposed cattle at a cost of $3,167.50, an average of $24.18 per head.

It was considered advisable to disinfect 117 stables, stock-yards, or other premises; and 13,157 *post-mortem* examinations were made upon the carcasses of bovine animals, of which 72 were found diseased with pleuro-pneumonia.

The total expenses in Pennsylvania from January 1 to November 30, 1888, have been $37,978.23, of which $4,411 was paid for cattle purchased for slaughter as either diseased or exposed. The remainder constitutes the expense for disinfection, inspection, tagging, registering, making *post-mortem* examinations, and maintaining that close supervision of all the cattle in the infected district which is absolutely essential for the complete success of the effort for the total eradication of pleuro-pneumonia.

It has been decided that the governor should issue a proclamation removing the quarantine restrictions at Philadelphia, to take effect December 15, 1888, and at that time the greater part of the force stationed there by this Department will be withdrawn. There is every reason to believe that Pennsylvania is now entirely free from this contagion, but it is deemed advisable to maintain a supervision of the cattle in transit through Philadelphia, and also to watch the rendering works and slaughter houses for a few months, in order that any re-appearance of it may be promptly detected.

THE WORK IN MARYLAND.

At the time the last report was written the work was being reorganized, and those stringent regulations governing the movement of cattle which have been mentioned in connection with the work elsewhere had just been applied to the infected district in Baltimore and vicinity. A new law was passed by the Maryland legislature at its last session recognizing the work of the Bureau in that State,

and providing for co-operation. Although there has been considerable opposition on the part of cow dealers, and in some cases of dairymen, and some violations of the regulations, the supervision has been maintained in an efficient manner and has resulted very satisfactorily.

It has been found difficult, and often impossible, to secure the indictment and vigorous prosecution of parties violating the laws and regulations, apparently because the sympathy of local officers was with the offenders of their district rather than with those who were trying to eradicate this disease. Fortunately the governor and the attorney-general of the State are interested in the success of the work, and realize its importance; and with their assistance a conviction has recently been obtained which it is believed will have a wholesome effect in preventing further violations, and thus make it unnecessary to continue the prosecutions.

There have been two outbreaks of pleuro-pneumonia in other counties, which were traced to cattle taken there from Baltimore, but in each case the extermination of the disease was promptly secured. At present all herds in the State known to be diseased have been slaughtered, and as but very few new cases have developed during the last sixty days it is believed that the plague is practically eradicated. It will be necessary to continue the supervision for a number of months after the last case has been disposed of before we can conclude that the last traces of the contagion have been destroyed. It so frequently happens that in some obscure country place a person will conceal the disease for months before it is discovered that a long period of watching is required to insure absolute safety.

From January 1 to November 30, 1888, there were inspected in Maryland 9,809 herds, containing 60,312 head of cattle. Of this number 5,055 were re-examined by deputies in addition to the professional inspections, and 17,749 were tagged with numbers and registered upon the books of the Bureau.

There were 74 new herds found affected with pleuro-pneumonia during the year, and these herds contained 1,189 animals, 124 of which were pronounced diseased when the inspection was made. There were purchased for slaughter during the same time 459 affected cattle at a cost of $12,330.13, an average of $26.87 per head; also 1,036 exposed cattle at a cost of $27,087.81, an average of $26.15 per head. The high average cost of affected cattle is due to the fact that many of them were but slightly affected or had so far recovered from the disease that they were as useful to the owner for the production of milk as before the attack. It is also to be remembered that the owner received for the exposed but still healthy animals the sum which was paid by the butcher for the carcasses in addition to the sum given above as paid by the Bureau.

It has been found necessary to disinfect 145 stables, stock-yards, or other premises during the year, and also to make *post-mortem* examinations upon the carcasses of 5,820 bovine animals, of which 507 were found diseased with pleuro-pneumonia.

The total expenses in Maryland from January 1 to November 30, 1888, have been $99,627.83, of which $39,417.94 was paid for cattle purchased for slaughter as either diseased or exposed.

THE WORK IN VIRGINIA.

Mention was made in the last report of the probable existence of pleuro-pneumonia in Virginia, but at the time of writing the inves-

tigation was not completed. The herd was located at Hampton, and proved to be affected with this disease. The contagion only spread to a very few animals outside of this herd which had come in contact with it. The infected animals were at once isolated and slaughtered as rapidly as possible. No cases of disease have appeared there during the last six months and we may therefore conclude that it has been eradicated.

The total number of affected cattle purchased in Virginia was 45, at a cost of $739, an average of $16.42 per head. The number of exposed cattle purchased was 53, at a cost of $641, an average of $12.10 per head. The total expense caused by this outbreak was $2,142.73, of which $1,380 was paid for diseased and exposed cattle.

THE WORK IN ILLINOIS.

While pleuro-pneumonia was practically eradicated from Illinois at the time the last report was written, there was still a number of animals in the infected district which it was deemed prudent to slaughter. It was also considered necessary for safety that the quarantine restrictions should be maintained until April 1, 1888.

There were slaughtered after January 1, 1888, 4 affected cattle, at a cost of $81.27, an average of $20.32 per head. There were also slaughtered 129 exposed animals, at a cost of $2,408.43, an average of $18.67 per head. The total expenses in Illinois from January 1 to November 30, 1888, were $5,946.69, of which $2,489.70 was paid for diseased and exposed cattle.

The prompt eradication of pleuro-pneumonia from Chicago and vicinity is worthy of more than a simple narration of the fact. It may well be considered one of the most important results ever accomplished by the Department of Agriculture. History gives few if any cases where the dairies of a city of the size of Chicago have once been infected with pleuro-pneumonia and where the disease has been eradicated without years of constant work and the expenditure of vast sums of money. Paris was infected more than one hundred years ago, and, in spite of the large number of veterinarians in that district, and of the stringent laws and regulations promulgated for its suppression, the disease still exists, and its ravages continue from year to year apparently undiminished.

A continued existence of the disease at Chicago would certainly have led to the infection of the whole country within a few years, and the ruin of a profitable cattle industry in the United States. Already the local restrictions placed by the authorities of many States upon the introduction of cattle from Cook County, and in many cases from the whole State of Illinois, had become extremely embarrassing to shippers and burdensome to the whole stock interest of the West. How these restrictions would have been increased by the spread of the plague to other States, and how we should have suffered from a leading article of food, impaired in quality and diminished in quantity, can be easily imagined. By a fortunate combination of circumstances it was possible to check the extension of the plague at once, and to extirpate it within a few months, but the risk of failure and the danger to the country have never been appreciated except by a few who were acquainted with all the facts.

With the publication of the notice giving information of the eradication of the disease and removing the quarantine restrictions which had been imposed by this Department, confidence was restored to

the stock-owners of the country, the irksome local restrictions were one by one removed, and soon the freedom of cattle commerce was again established.

No information has been obtained during the year which would lead to the conclusion that the contagion of pleuro-pneumonia exists in any part of the country west of the Alleghany Mountains. There is, consequently, good reason to believe that it is now confined to the Atlantic sea-board, and with every month that elapses without hearing from it elsewhere this conclusion is strengthened. With the quarantine restrictions now in force in the infected districts there is but little danger of the plague again finding its way to the West, and with the continual repression and diminution of it at all points this danger, small as it is, is constantly becoming less. If this work is continued for another year it seems probable that the contagion will have entirely disappeared from the United States by the expiration of that time.

THE WORK AS A WHOLE.

It will be seen from the above that there has been constant and satisfactory progress during the year at all points where the disease exists. The work has been heavy and expensive, and the expenditures for the eleven months covered by this report have been greater than the appropriation for any fiscal year. It was only by so planning that the most costly work would come in the latter part of one fiscal year and at the beginning of another that the operations could be sustained in an efficient manner without an increased appropriation. Even with this plan in mind it was necessary to suspend all slaughtering of animals and much of the other work for over six weeks in May and June in order to avoid a deficiency. Although the total expenditures of the first five months of the present fiscal year for the entire work of the Bureau have averaged $46,178.68 per month, or at the rate of $554,144.16 per annum, it appears certain that the decrease which has been made, and which can be carried still further as the work proceeds, will bring the total for the year within the sum appropriated, and this without the necessity of interrupting the operations.

Including all the districts in which pleuro-pneumonia has existed, there were inspected from January 1 to November 30, 1888, a total of 35,604 herds of cattle, containing 305,280 animals. Of this number 106,415 were re-examined by the non-professional assistants in addition to the veterinary inspections, and 183,257 were tagged with numbers and registered upon the books of the Bureau.

There were 631 new herds found affected with pleuro-pneumonia during the year, and these herds contained 8,643 animals, 1,446 of which were pronounced diseased when the inspections were made. There were purchased for slaughter during the same time 2,649 affected cattle, at a cost of $67,695.93, an average of $25.55 per head; also 5,490 exposed cattle, at a cost of $131,227.74, an average of $23.90 per head.

It has been found necessary to disinfect 1,879 stables, stock-yards, or other premises, and also to make *post-mortem* examinations upon the carcasses of 43,176 bovine animals, of which 3,426 were found diseased with pleuro-pneumonia.

The total expenses of the pleuro-pneumonia work from January 1 to November 30, 1888, have been $481,586.55, of which $198.923.67

was paid for cattle purchased for slaughter, as either diseased or exposed. The remainder constitutes the expense for inspection, disinfection, tagging, registering, and supervising the movement of cattle, of *post-mortem* examinations, and of all the various expenses necessary to insure the prompt discovery of this plague when it appears in any herd, and to prevent the further extension of the infection.

The following table shows a résumé of the pleuro-pneumonia work from January 1 to November 30, 1888, as given in detail above:

Table showing the work of the Bureau of Animal Industry for the eradication of pleuro-pneumonia from January 1 *to November* 30, 1888.

	New York.	New Jersey.	Pennsylvania.	Maryland.	Virginia.	Illinois.	Total.
Herds inspected	12,333	8,018	5,291	9,809	13	140	35,604
Cattle inspected	99,726	72,095	72,565	60,312	297	285	305,280
Cattle re-examined by deputies	62,184	20,413	18,763	5,055	....	....	106,415
Diseased cattle found by inspection	691	581	49	124	1	....	1,446
Post-mortem examinations	15,538	6,846	13,157	5,820	103	1,712	43,176
Diseased cattle found by *post-mortem* examinations	2,287	514	72	507	46	....	3,426
Cattle tagged	100,370	13,318	51,820	17,749	....	....	183,257
New herds found affected	323	210	23	74	1	....	631
Animals in affected herds	4,647	2,508	260	1,189	39	....	8,643
Diseased cattle purchased	1,576	502	63	459	45	4	2,649
Exposed cattle purchased	3,196	945	131	1,036	53	129	5,490
Premises disinfected	1,339	275	117	145	2	1	1,879

Résumé of the expenditures in the pleuro-pneumonia work from January 1 *to November* 30, 1888.

Items.	New York.	New Jersey.	Pennsylvania.	Maryland.	Virginia.	Illinois.	Total.
Salaries	$109,694.44	$36,239.05	$27,886.73	$46,454.17	$601.56	$3,062.60	$223,938.55
Traveling expenses	17,983.97	8,327.19	3,486.73	11,117.92	141.62	220.30	41,277.73
Miscellaneous expenses	9,714.03	2,707.36	2,193.77	2,637.80	19.55	174.09	17,446.60
Affected cattle	40,976.53	12,325.50	1,243.50	12,330.13	739.00	81.27	67,695.93
Exposed cattle	72,410.50	25,512.50	3,167.50	27,087.81	641.00	2,408.43	131,227.74
Average paid for affected cattle	26.00	24.55	19.73	26.87	16.42	20.32	25.55
Average paid for exposed cattle	22.65	27.10	24.18	26.15	12.10	18.67	23.90

We have now entered upon the most critical period in the work for the eradication of this disease. In all of the infected States the animals known to have been diseased or exposed have been slaughtered with few exceptions, but in Maryland, New Jersey, and New York the plague continues to develop at greater or less intervals, and, consequently, newly infected herds are discovered. In Maryland and New Jersey, where the work has been longest in progress, these new infections are becoming less and less frequent. Even in the worst infected districts on Long Island the prevalence of the malady has been greatly diminished. With this decrease in the amount of disease, the reason for the stringent regulations becomes less apparent to the cattle-owners, to prosecuting officers, and to citizens generally. It is therefore much more difficult to enforce the laws and the regulations made under them; flagrant violations become more frequent, and in some cases efforts are made, usually by cow-dealers, to propagate the disease.

These facts show the importance of maintaining the quarantine

restrictions until the last vestige of the contagion has disappeared. And above all should we be able to preserve the interstate channels of commerce free from infection. The large sum of money expended and the encouraging progress of the work, with the rapid approach of the time when the country could be declared free from this plague, emphasize the necessity of adopting every precaution to secure early and complete success. But how is this to be accomplished? Evidently by enforcing every regulation against the spread of the disease until the contagion has entirely disappeared.

I have already mentioned the growing disposition on the part of State officials to relax their regulations, to allow violations to go unpunished, to remove restrictions before safety has been assured. This disposition is alarming, because just as the whole pleuro-pneumonia infection in this country arose from a single case of the disease, so now the escape of one affected animal may undo all that has been accomplished by two years of indefatigable labor and by an expenditure of nearly $1,000,000.

To guard against this danger, I would respectfully and most earnestly recommend amendments to the act establishing the Bureau of Animal Industry imposing a penalty upon any person who removes or causes to be removed any bovine animal from a section declared by the Commissioner of Agriculture to be an infected district to any other State or Territory, or who transports or causes to be transported any such animal upon any railroad or vessel which forms part of a transportation line from one State or Territory into another. At present there is no penalty, except for those who knowingly ship a diseased animal from one State to another. Experience shows that it is impossible to prove that a person knows an animal to be affected. It is also more dangerous to ship exposed animals than affected ones, because the latter are easily detected as a rule, while the former do not show the symptoms for two or three months, and during this time may scatter the contagion among many animals and herds. It is equally important to prevent the shipment of diseased and exposed animals within a State, except upon lines of railroad and upon steamboats which form a portion of our great interstate commercial channels.

It is worthy of remark that there has been no trouble in enforcing the rules and regulations in country districts where the population is made up of farmers. The native American farmer has always assisted in stamping out the disease and has been scrupulously careful to carry out to the letter any measures that he was called upon to observe. The result is that country outbreaks are soon under control and quickly eradicated. Not so, however, with city outbreaks. Here we come in contact with an entirely different element of our population. The city cow-owner, as a rule, is in debt to the dealer from whom he buys his cow. He is poor, ignorant, often unable to speak our language, unscrupulous as to the health of his animals or the character of the milk he sells, and not infrequently appears to consider it his duty to violate the regulations or the statutes rather than to observe them.

In farming districts, therefore, it matters little whether the laws are perfect or imperfect, or whether there are or are not penalties for their violation; it is seldom that they are appealed to, and the work of eradication goes smoothly on until it is completed. In city districts the conditions are exactly opposite. When the inspectors come upon the premises they are met as enemies; too often they are

threatened with violence; diseased cattle are surreptitiously sold by the owners, and taken into other herds by dealers whose sales are increased by the misfortunes of their customers. With such people, harsh measures are necessary or the work could never be completed.

The laws should cover all acts which would tend to spread the disease, and there should be penalties applicable to all violations. Without these the time and expense required for complete success must be indefinitely increased.

GLANDERS.

In addition to the order of the Commissioners of the District of Columbia referred to in my previous report, by which the Chief of the Bureau of Animal Industry was made District veterinarian for the purpose of discovering and eradicating pleuro-pneumonia, a subsequent order has been issued which gives him authority to investigate as to the existence of glanders and to kill affected animals without compensation to the owner. The investigations so far made show the prevalence of this malady to a considerable extent among the horses in the District. From here affected animals have been frequently taken into Maryland and Virginia, scattering the disease and causing severe losses in those States. The presence of such a pest, dangerous not only to the equine race but equally fatal to mankind, calls for energetic measures of suppression. To this end prompt action has been taken whenever the disease has been discovered and affected animals have been killed as soon as possible after a satisfactory diagnosis was reached. At the same time great care has been exercised that no animals should be condemned unless they presented the pathognomonic evidences of the affection. When practicable a *post-mortem* examination is always made to confirm the *ante-mortem* diagnosis. The number of horses killed in the District of Columbia because affected with glanders was: July, 1; August, 0; September, 2; October, 10; November, 1; December, 12; total, 26.

PREVENTION OF HOG CHOLERA.*

ISOLATION, DISINFECTION, AND CLEANLINESS AS PREVENTIVE MEASURES.

It is frequently necessary to apply preventive measures before infectious diseases have actually appeared in a herd. The disease may have appeared on a neighboring farm and the problem then arises, How can the disease be prevented from spreading to other farms? How can the surrounding farms keep the disease from their premises?

The sources and channels of infection are as follows, the most common and important being placed first:

(*a*) Pigs purchased from infected herds, or coming in contact with those from infected farms, or running over ground occupied by diseased swine within a period of two or three months.

(*b*) Infected streams may communicate the disease to herds below the source of infection.

(*c*) Virus may be carried in feed, implements, and on the feet and clothing of persons from infected herds and premises.

(*d*) Winds, insects, birds (particularly buzzards), and various animals may transport hog cholera virus.

* Equally applicable to swine plague.

In regard to *a*, it may be said that no pigs should be purchased from any locality until one year after the death of the last case of cholera. There are frequently, near the end of an epizootic, chronic cases which may live for three or four months without showing any distinctive signs of disease until they suddenly die. The *post-mortem* examination usually reveals extensive ulceration of the large intestine. The disease may thus linger in a herd long after all danger has apparently subsided. By bringing any chronic cases in contact with hitherto unexposed healthy swine the disease may spring up anew, as a dying fire would among fresh fuel. Although our experiments have shown that the disease germs may all disappear from the soil in three or four months, the uncertainty of knowing whether there are any chronic cases continually adding fresh virus to the soil makes the period of one year not too long. It is advisable, in districts where hog cholera is very prevalent and is rarely absent for any length of time, for farmers to raise their own pigs and not trust to any animals from outside. In this way infection may be at least in part kept under control. When animals have been obtained from places which are not above suspicion, they should not be brought in contact with swine already on the place, but quarantined as far as possible from them and kept under careful observation for at least one month.

(*b*) Perhaps the most potent agents in the distribution of hog cholera are streams. They may become infected with the specific germs when sick animals are permitted to go into them, when dead animals or any part of them are thrown into the water, or when pig pens are drained into them. They may even multiply when the water is contaminated with fecal discharges or other organic matter. Experiments in the laboratory* have demonstrated that hog cholera bacilli may remain alive in water for four months. Making all due allowance for external influences and competition with other bacteria in natural waters, we are forced to assume that they may live at least a month in streams. This would be time enough to infect every herd along its course.

(*c*) Hog cholera germs are not immediately destroyed by drying. Laboratory experiments show that they may retain their vitality from two to four months. Hence it is not difficult to see how a person walking on infected ground and among infected animals may carry on his shoes and clothing dried germs of the disease to any neighboring herd. For the same reason, hog cholera germs may be carried from infected grounds to others by feed, and by farming implements which have come in contact with infected ground.

(*d*) There is no reason to suppose that currents of air have much influence in spreading the disease. Observations at the experiment station of the Bureau have left no doubt that healthy pigs may be kept on the same farm with diseased ones in pens not more than 100 feet from the sick without becoming infected, provided the infection is not carried in feed and implements, or on the shoes and clothing of persons, from the sick to the healthy. Moreover, the disease is an intestinal malady, and all evidence points to infection through the food rather than through the air inspired.

The agency of flies and other insects is, perhaps, equally limited when infection is to be carried from one place to another. Our experiments show very well that the sting or bite of an insect can not be

*See bulletin on hog cholera.

sufficient to produce the disease. It is possible, however, that they may carry the virus from one place to another in the same yard. This will be discussed more fully under another head.

The agency of buzzards in distributing the disease in the Southern States seems probable, although there is no positive proof. These birds will readily consume carcasses of dead swine. If the hog cholera germs are not destroyed by digestion it is reasonable to assume that the feces contain the living germs, which may cause the disease to break out at some distant place. Of course the remedy would be to immediately destroy or bury dead animals.

There is some reason to believe that rats, dogs, and perhaps other small animals may carry the germs upon their feet or in their hair and thus infect premises. It is probable that the contagion is only rarely transported in this manner, but there are outbreaks the origin of which it is difficult to explain otherwise.

Granted, then, no communication between infected and uninfected farms, there still remains the danger of infected water-courses, upon which it is impossible to lay too much emphasis. In fact, if the disease exists anywhere along a stream all farms below that point are liable to infection unless use of the water in any form whatever is given up during the season.

By paying particular attention to these points there is no doubt that the disease can be warded off even when in the immediate neighborhood. Hog cholera is analogous to typhoid fever, dysentery, and Asiatic cholera in man in many particulars, and there is a quite unanimous opinion that these diseases are most commonly transmitted through drinking water. The same may be predicated of hog cholera, and the mysterious spread of this plague will no doubt frequently be understood by examining the water-courses.

When the disease is in the neighborhood it has been customary with some to feed swine on a so-called "preventive" medicine. These are frequently prepared or invented by individuals who have little, if any, knowledge of the action of medicines. The outcome is that the animals fed with these unknown compounds are not only not benefited, but their vitality is actually reduced, and when the disease appears it destroys the weakened animals much more easily. The writer has made *post-mortem* examinations of several animals in the West where such preliminary treatment was going on, and the peculiar changes of the internal organs, not like any known disease, could only be referred to the action of such preparations. It must be remembered that there are very few medicines which are not injurious or poisonous in large doses. They should not be used excepting under special conditions, and only given as recommended by those who have been trained to know the peculiar value and effect of drugs.

The condition of the animals themselves is of great importance in favoring or preventing infection. When pigs are fed with liquids in which the specific bacilli only are present those that have been deprived of food for some time previous take the disease, while those whose stomachs contain food that is undergoing digestion do not take it readily. If, besides starving the animal, they are fed with some alkaline solution by which the alkalinity of the stomach is increased, the pathogenic effect is still more pronounced. Any disorder of digestion by which the secretion of gastric juice is diminished or checked and the mucus is increased in quantity will increase the susceptibility of the animal to infection, because the alkalinity of the mucous membrane will favor rather than destroy the virus.

Any mode of feeding which produces constipation and overdistension of the large intestine is likely to favor the disease, as the virus is retained for a longer time. During epizootics, therefore, besides the preventive measures suggested, the animals should be carefully fed upon food which tends to keep the bowels open and the feces soft, and which does not interfere with normal digestion.

When there is a suspicion that a herd has been infected, although the disease has not yet appeared, disinfection and all the rules laid down below, as if the disease were actually present, should be carried out with great care.

When hog cholera has appeared in a herd or on a farm, precautions should be taken for two reasons: (1) To prevent the virus from being carried to other farms and infecting other herds; (2) to prevent the loss of the entire herd, or, if this is not possible, to stamp out the disease in such a way that the ground shall not infect healthy animals subsequently introduced.

The rules under the first head should be prescribed by law to protect property from the consequences of the carelessness or the willfulness of those who refuse to take proper precautions. They may be summarized as follows:

(*a*) The dead animals should be immediately disposed of either by burial or by burning, or if they are taken to some rendering establishment their transportation should be governed by well-defined rules which will prevent the dissemination of virus on roads, in wagons, cars, etc.

(*b*) Streams should be carefully protected from pollution.

(*c*) No animals should be removed from any infected herd or locality to another free from the disease, except for slaughter, for at least six months after the last case of disease has died or recovered.

(*a*) The proper disposal of dead animals is a matter of great importance, for the bodies not only contain the germs of the disease, but the latter will multiply enormously during summer heat in the internal organs after life has been extinguished. Each dead body must therefore be regarded as a focus of the disease unless properly disposed of. It may be buried. In such case it must be so deep that no animal can get at it. It should be covered by a layer of powdered or slaked lime several inches thick, and the ground over the body likewise sprinkled with a thin layer of the same. If the carcasses are burned, care should be taken that any parts not consumed are buried as directed. If they are carried away some distance to rendering establishments, employés of such establishments should be compelled to wrap around the carcasses strong cloths wetted with a 2 per cent. solution of carbolic acid, so as to protect the roads from the virulent drippings.

(*b*) The danger from infected streams has already been mentioned at length. These must be protected by law in such a way that no sick animals should be allowed to go near them, and that no carcasses be thrown into them or deposited where drainage may carry the virus from the body into the water. Nor should the drainage from pens be permitted to flow into them.

(*c*) Hogs are frequently affected with cholera of a mild form, which lasts several months before some form of septic infection or degenerative changes in the internal organs produce death; hence it is important to insist upon knowing when the last case of disease occurred. Since it has been demonstrated that hog cholera germs may remain alive in the soil from three to four months, this rule will not appear unreasonable as a safeguard.

These rules will be sufficient, if properly executed, to confine the disease within narrow limits. There is no doubt that hog cholera virus dies out over the greater part of our country after epizootics have swept over it. We have no reason to believe that it can survive in the soil from one end of the year to the other. It is, in fact, highly probable that it is transported and distributed from a few places where for some reason cases have occurred throughout the year and have thus kept the virus alive. There are no experiments on record which show that the hog cholera germs may be found in the soil and water independent of the disease. They have been looked for but have never been found excepting in the body or discharges of diseased swine.

In view of the fact that the disease can be kept under control, the legislatures of those States which suffer most severely from this plague should take steps to enact rules similar to those formulated above. The States of Kansas and Nebraska have on their statute books laws of this character, which read as follows:

KANSAS.

AN ACT to prevent the spread of disease among swine.

Be it enacted by the legislature of the State of Kansas, It is hereby made the duty of every person who owns or who has the control of any hog that has died of any disease to bury or burn the same within twenty-four hours after such hog has died: and any person who knowingly fails or refuses to comply with the provisions of this section shall be deemed guilty of a misdemeanor, and upon conviction thereof shall be fined not exceeding one hundred dollars.

SEC. 2. Whoever shall knowingly barter or sell any hog afflicted with any disease without giving full information concerning said disease shall be deemed guilty of a misdemeanor, and upon conviction thereof shall be fined not exceeding one hundred dollars.

SEC. 3. Whoever shall knowingly barter or sell any hog which has died of any disease shall be deemed guilty of a misdemeanor, and upon conviction thereof shall be fined not exceeding one hundred dollars.

SEC. 4. Whoever shall throw or deposit a dead hog in any river, stream, creek, or ravine shall be deemed guilty of a misdemeanor, and upon conviction thereof shall be fined not exceeding one hundred dollars.

NEBRASKA.

AN ACT to prevent the spread of hog cholera and other kindred diseases, and prevent traffic in animals dying from infectious or other diseases.

Be it enacted by the legislature of the State of Nebraska: That it shall be the duty of the owners of swine or other domestic animals dying from cholera or other diseases, within twenty-four hours after their death, to cause the carcasses of such animals to be suitably buried or burned up, on the premises owned or occupied by such person.

SEC. 2. If the owner of any swine or other domestic animals dying from cholera or other disease, or any other person shall sell or dispose of the carcass of such swine or other domestic animals, to any person for the purpose of manufacturing the same into soap or rendering the same into lard, or for other purposes, or if any person shall buy, or otherwise obtain the carcass of any swine or other domestic animals, dying from cholera or other disease for manufacturing purposes as aforesaid, or any other purpose except that of burial or burning, as provided in the preceding section, every such person shall upon conviction be fined in any sum not less than twenty-five dollars nor more than one hundred dollars, or be imprisoned not exceeding six months.

SEC. 3. Whereas an emergency exists, this act shall be in force and take effect from and after its passage.

Approved, March 4, 1885.

These laws, although not sufficiently explicit, touch upon the most important points, and are great strides in the right direction. We

would suggest laws embodying the three heads in their entirety as given above under *a*, *b*, and *c*, together with directions for their proper execution. The disease spreading so easily and rapidly requires great promptness of action and quite different rules from those which must be adopted in the suppression of glanders or tuberculosis, for example. The difference is due to the nature of the specific microbe so unlike those causing the two diseases mentioned.

It is not strange that so little attention has been paid to the restriction of this disease in the past, since legislators and boards of health and State veterinarians have had no scientific basis upon which to frame laws. Even now efforts are being made in various quarters to controvert or openly deny the accuracy of the investigations and results obtained by the Bureau, and throw the whole subject back into the chaos in which it was but a few years ago. This must have anything but a salutary effect upon those intrusted with the framing and execution of specific laws for the protection of domesticated animals.

Having thus far dwelt upon the means which must be resorted to prevent the spread of the disease from one place to another, it becomes necessary to consider some of the measures that should be employed in checking it after it has once taken foothold in a herd. But how are we to recognize the disease? To answer this question it may be well to recapitulate briefly some of the more important features of the malady in as simple language as possible.

It is quite common for the disease to announce itself by a few sudden deaths. The stricken animals may seem well a day, perhaps only a few hours, before death. In order to remove any doubts as to the precise nature of the disease it is best to examine one or more of the animals before burying or burning them. This should be done in a secluded place which pigs can not reach and the ground thoroughly disinfected as will be described later. The disease in the sudden cases can be easily recognized. The spleen is as a rule very black and enlarged. Spots of blood from the size of a pin's head to a quarter inch or more will be seen in the fat under the skin on the intestines, lungs, heart, and kidneys. The lymphatic glands are purplish instead of a pale pink. When the large intestines are opened they are found covered with these dark spots of blood more or less uniformly and entirely. Often the contents are covered with clotted blood. Any or all of these may be considered as signs of the disease in its most virulent form. In many outbreaks the early cases do not succumb so rapidly. They grow weaker, lie down much of the time, eat but little, and usually have diarrhea. Most of such cases may linger for weeks, meanwhile scattering the poison in the discharges. The disease may be recognized in these cases as soon as they are observed to act suspiciously, and there should be no delay in determining at once the nature of the disease. When the animal has been opened the large intestine should be carefully slit up and examined, beginning with the blind or upper end. There will be seen roundish yellow or blackish spots, having an irregular depressed, sometimes elevated surface. These spots are ulcers and correspond to dead portions of the mucous membrane, and they are frequently seen from the outside as soon as the animal is opened. Sometimes the membrane has been entirely destroyed.

In order to comprehend fully the reasons for the preventive measures suggested, let us briefly trace the various ways in which hog

cholera bacteria may pass from a diseased or dead animal to a healthy one.

Pigs may become directly infected by feeding on the carcasses of such as have died of the disease, or by feeding on the feces and urine of sick animals; or they may become indirectly infected by feeding upon material in which hog cholera bacteria are accidentally present and in which they have multiplied. This would include milk, water, and perhaps most vegetables in a boiled condition. It has been pointed out in preceding pages that hog cholera bacteria multiply very abundantly in milk, especially in warm weather; that they remain alive in water for months, and that they multiply upon boiled potato. It has also been shown by an extended series of experiments that they may remain alive in the soil for from one to four months. The sources of infection are thus numerous enough. It has likewise been demonstrated that these disease germs will resist drying for several months. Hence dried discharges of the sick, or the dried bodies of dead animals, are still infectious.

The channel of infection is, in most cases, the food and drink. This has been frequently demonstrated and emphasized in foregoing reports.

The food, after leaving the stomach, passes in a liquid condition through the small intestine, so that this never seems filled; in fact, its only contents is a coating of semi-liquid matter over the mucous membrane. It passes through the small intestine quite rapidly, but on reaching the large intestine the undigested remains become more consistent, because the liquid is re-absorbed and is kept here for some time. The bacteria, if not destroyed by the gastric juice, pass quickly through the small intestine, but in the large intestine they begin to multiply and attack the mucous membrane, which they destroy. Thus the feces or discharges of diseased pigs, wherever deposited, scatter larger or smaller quantities of the virus in this way, completing the circle of infection.

In order to prevent the remaining healthy animals in an infected herd from taking the disease, the following measures are suggested as of importance, some or all of which may be carried out according to circumstances:

(*a*) Removal of still healthy animals to inclosed uninfected ground or pens as far as possible from infected localities.
(*b*) Destruction of all diseased animals.
(*c*) Careful burial or burning of carcasses.
(*d*) Repeated thorough disinfection of the infected premises.
(*e*) Great cleanliness, both as to surroundings and as regards the food, to prevent its becoming infected.

(*a*) The importance of this measure need not be insisted upon after what has been stated of the various ways in which pigs may be infected. The distance to which they may be removed will, of course, depend on circumstances. They should be kept so far away that there can be no means of communication either by direct contact, by drainage of the surface of the soil, or by gusts of wind. They should not be kept too closely confined, for if the disease should have attacked one or more, and not manifested itself before removal, the infection would become general. Even after this precaution is taken, latent disease among such as are apparently healthy may infect the new grounds and the remaining healthy animals. This danger is increased by the fact that not unfrequently a number of animals become infected from the same source at the same time. Some will

show symptoms very speedily; in others the disease will remain latent for a longer time. Under such circumstances it is impossible to properly isolate the well from the sick. Then there is the difficulty of preventing the healthy animals from carrying the virus on the skin and feet into their new quarters. These drawbacks may be in part overcome by very prompt action when the first signs of disease appear in a herd, before the virus has had an opportunity of being scattered about. The bodies of those to be removed may be fairly well disinfected by pouring over them a 2 per cent. solution of carbolic acid, and forcing them to walk through such a solution.

(*b*) This measure is recommended to prevent the further spread of the virus by the diseased animals. In view of the fact that few recover; that even these few are stunted and of little value; that there is no reliable means of treatment which will eventually cure, destruction of all sick animals is the simplest and most economical procedure in the end.

(*c*) The disposal of carcasses has already been discussed. This very important measure should never be lost sight of.

(*d*) Among the various disinfectants which can be recommended are the following:

No. 1. Slaked or unslaked lime, used both as a powder and as slaked lime containing about 5 to 10 per cent. of dry lime (from one-half to 1 pound of lime to a gallon of water).

No. 2. Crude carbolic acid, prepared by adding to the crude carbolic acid, obtainable from druggists at about 90 cents a gallon, an equal quantity of ordinary sulphuric acid. This mixture is to be carefully added to water in the proportion of 2 ounces to 1 gallon of water (about 1½ per cent. by volume).

No. 3. A 1 per cent. solution (by volume) of ordinary sulphuric acid (1¼ ounces of the acid to 1 gallon of water).

No. 4. A 2 per cent. solution of carbolic acid. This is prepared by heating the crystals slightly until they melt and adding the resulting liquid to hot water, in the proportion of 1¼ ounces to half a gallon of water. (A pound of carbolic acid, crystallized, retails at 55 cents.)

No. 5. Boiling water.

The careful laboratory experiments with these disinfectants, upon which their practical application is based, are given in the forthcoming bulletin on hog cholera. We shall confine ourselves in this place to a description of their employment.

Disinfectants are substances which, in solutions of a certain strength, are capable of destroying disease germs. Consequently they should be applied wherever the disease germs are supposed to be. In case of hog cholera they are attached to the sides and floorings of pens, and to the various utensils used in cleaning them. They are mixed with the earth over which the diseased animals have run, or in the water which they have frequented. In the report of the Department for 1886 the use of mercuric chloride (corrosive sublimate) was recommended, as it is a powerful disinfectant. Since that time other disinfectants have been tested which are equally cheap and easily procurable. The main objection to mercuric chloride is its extremely poisonous character, which makes it undesirable to deal with it. This substance has therefore been thrown out, in spite of its powerful germicide properties, from our list of available disinfectants.

The wood-work of pens, fences, flooring, etc., is best disinfected by using upon it, with a broom, solution No 2, until thoroughly wet. In preparing this solution it should be stated that the mixing must be done in a glass bottle or jar, and the mixture poured slowly into the proper amount of water in a wooden pail. This should be rinsed

out after using to prevent the acid from slowly destroying the iron hoops.

Whenever No. 2 is not obtainable No. 3 may be used in its place, which seems to be equally efficient.

Lime is a very efficient disinfectant for hog cholera. Experiments have shown that a solution containing only .02 per cent. will destroy the bacteria. When much organic matter is present, as much as .5 per cent. to 1 per cent. may be necessary. We recommend the proportions given under No. 1, which give from ten to twenty times the strength required. The resulting liquid is not too thick to be easily manipulated. It may be used on wood-work as a whitewash, and it may be spread as a thin layer over the soil which has been infected.

The 2 per cent. solution of pure carbolic acid should be used whenever No. 2 may act injuriously by virtue of the sulphuric acid which it contains.

In general we recommend the use of No. 2 or No. 3 as often as it may seem necessary. It should be dashed upon the infected pens, troughs, tools, and over the infected soil. When there is no objection to lime this may be used on the soil, as it is equally efficient. The discharges should be covered with powdered or slaked lime, and this should be thrown in abundance into pools, or wherever water stagnates. In the case of troughs for feed, iron tools, etc., which are liable to injury, the disinfectant should be washed away with boiling water if this is at hand. Boiling water will destroy hog cholera germs by simple contact, and the disinfection will thus be made more complete. Shoes may be disinfected by rubbing them with solution No. 4.

It must be carefully borne in mind that no manure from sick pigs should be removed until it has been treated with disinfectants. The cleaning must be done after disinfection and not before, to prevent the dissemination of living virus.

The agency of mice and rats in transporting virus will depend upon the promptness and thoroughness with which disinfection and cleanliness are practiced. Mice are more dangerous than rats, in so far as they may take the disease by feeding. Flies can only carry such small quantities of the virus that they are not likely to prove dangerous if disinfection and cleaning of feed troughs is attended to.

If these measures are carefully carried out the disease may either be checked or else mild cases only will appear, owing to the small quantity of poison which the animals are likely to consume with the food.

The epizootic may be terminated by the destruction of most of the herd. This unfortunately is usually the case. What precautions must be taken to prevent subsequent outbreaks?

If only a few animals remain it is best to slaughter them, as they are likely to suffer with the disease in a mild form and continue to infect the premises. If no more animals remain, there should be a final thorough disinfection and subsequent cleaning of the whole exposed territory, including every nook or corner where the disease has existed. This should be done with solution No. 2 or No. 3, as directed, used as freely as possible. After one or two days the ground may be covered with a thin layer, one-eighth inch or more, of slaked lime in the strength above given and left undisturbed. If there is no objection to whitewash this may be applied to infected wood-work as an additional safeguard. Even after this thorough treatment it is best not to place any fresh pigs on the premises for at least four months after the final disinfection. When animals still remain that

have been exposed and have not taken the disease, no fresh animals should be introduced for at least six months after the termination of the outbreak. The disinfection must have been equally thorough.

There are often conditions which make it necessary in certain kinds of business to immediately introduce fresh pigs upon a place which has been infected with hog cholera. In such cases, the destruction of all remaining animals and the thorough disinfection of the premises are the only things to be relied upon to prevent a fresh outbreak.

After all this trouble has been taken, there is still remaining the danger of a fresh introduction of the disease, and we would therefore again call attention to the rules for prevention which are given above. These, after all, must be considered as most important. It is much easier to keep the disease away than to eradicate it after it has been introduced, without great loss of time and money. We would also suggest that in those regions where the danger from hog cholera epizootics is always present, the methods of keeping hogs be simplified in such a way that disinfection may be practiced without too much labor and uncertainty as to the results. It is only necessary to visit a few farms to be convinced of the difficulty that may be met with in endeavoring to eradicate the disease. The hogs are allowed to stray into the most out-of-the-way places when sick, instead of being kept in inclosures of definite form and size, which are readily accessible. The poison is thus scattered in such a way as to make disinfection impossible. It is certainly not necessary in raising pigs to allow them to stray into arbors, behind hedges, hide themselves under barns and out-houses. In some farms which we have visited, and which were said to be affected with hog diseases most of the year, there seemed to be no places about the house or garden where pigs did not go. Under such circumstances disinfection is quite impossible. The pens and other wooden structures, fences, etc., are also apt to be in a very dilapidated condition, so that cleaning is very much complicated. Even under such circumstances the germs will finally perish without disinfection if enough time be given, since they gradually die in the soil and water, as our experiments have shown. A period of from six to nine months after all animals have been removed will be, in general, sufficient to purify the soil of these disease germs. In fact, the natural spontaneous disinfection is very likely accomplished in many cases in from three to four months, but it would not be safe to rely upon this.

TREATMENT OF HOG CHOLERA.

Upon this subject very little should be said, for the reason that diseased animals are a source of poison and a menace to healthy animals, and should be destroyed. Moreover, treatment is exceedingly unsatisfactory, as the disease either terminates fatally, whatever remedies are used, or makes the animal useless if it should recover. We therefore urgently recommend slaughter of the sick and thorough disinfection as the safest and most economical treatment in the end.

Treatment, however, is resorted to by a large number of owners of swine. The number of specifics, so called, which are being advertised is legion. We have tried some of the best recommended and found them of no avail. Nor is there any "specific" known in the range of veterinary or human medicine that will cure diphtheritic and ulcerative disease of the large bowels except time, combined with careful dieting, rest, and a few palliatives to relieve pain. It is im-

possible to carry out this treatment on swine. The success frequently reported with specifics in hog cholera is very probably due to the fact that the treatment is usually adopted when the acute outbreak is over and the plague has assumed a chronic character. The affected swine linger for a time with very slight symptoms of disease, and this change is credited to the "specific" employed.

Remembering that the severest injury is done to the walls of the large intestines in this disease, we regarded it important to determine what medicine would give a prompt and copious evacuation of the bowels in the very beginning of the disease. Various medicines were tried by Dr. Kilborne, at the Experiment Station, among others the following:

(1) *Calomel and jalap.*—February 20, 1888, to No. 463, 30 grains calomel; No. 467, 23 grains jalap; No. 468, 30 grains each of calomel and jalap. February 21, same dose given again to Nos. 463 and 468. No result.

(2) *Calomel.*—March 7, to Nos. 441 and 442, each 1 dram of dry calomel. March 8, to 441, same dose mixed with castor-oil; to 442, about 1½ drams with castor-oil.

Result: No. 441 was freely purged after second dose, continuing for twenty to twenty-three hours. No. 442 was freely purged after sixteen hours, continning sixteen to twenty hours, when it died. At autopsy were found intense inflammation of stomach; superficial necrosis of the mucosa of large intestine, with deep reddening resembling hog cholera. No bacteria found in cultures from spleen. This inflammation was no doubt due to the calomel.

(3) *Calomel.*—March 8, Nos. 463 and 468 received each 1 dram of calomel in 2 drams of castor-oil. No. 468 was purged freely in twenty hours, continuing thirty-six hours. No. 463 was purged in sixteen hours, and made ill for several days.

(4) *Epsom salts.*—Nos. 403 and 405 (weight, 50 pounds) received each 1 ounce. Bowels slightly relaxed for one or two passages. Nos. 339 and 377 (weight, 50 pounds) received each 2 ounces in water. No. 339 was purged and made slightly ill. No effect on 377.

(5) *Barbadoes aloes.*—Nos. 402 and 404 (weight, 50 pounds) received half a dram each. No effect. Nos. 372 and 380 (weight, 65 pounds) received each 2 drams, mixed in molasses. No effect. The same animals, five days later, received each 4 drams with molasses. No effect, except discoloration of feces.

(6) *Castor oil and turpentine.*—Nos. 387 and 388 (weight, 50 to 60 pounds) received each 1½ ounces castor-oil and one-sixth ounce turpentine. No effect. No. 387 received, five days later, 2½ ounces oil and one-sixth ounce turpentine. No. 388 received, five days later, 2½ ounces oil and one-third ounce turpentine. No effect.

(7) *Linseed oil and turpentine.*—Nos. 383 and 399 (weight, 50 to 60 pounds) received each 2½ ounces oil and one-sixth ounce turpentine. No effect. No. 383 received, five days later, 4 ounces oil and one-sixth ounce turpentine. No. 399 received, five days later, 4 ounces oil and one-third ounce turpentine. Both were made sick for a day or two. No catharsis.

These trials show how difficult it is to cause movement of the large bowels in swine, and they also suggest that this very sluggishness may make them susceptible to inflammation and ulcerations such as we find in hog cholera and frequently in swine plague.

It was our intention to obtain a cathartic which would freely purge without causing any inflammation or irritation of the large intestine. Of those tried, calomel is the only available one. This must be carefully given, as it may produce the very inflammation which it is designed to check, and destroy life, as was actually done in the second experiment.

Concerning calomel, Ellenberger* says:

Calomel (in combination with castor-oil) is especially serviceable with swine; with larger animals when the contents of the intestinal canal are to be disinfected and in inflammatory fevers. It should be given to ruminants with the greatest caution.

It was our purpose to try calomel after having made these trials upon healthy animals, when the disease died out at the Experiment Station and further investigations had to be postponed.

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* *Lehrbuch d. allgemeinen Therapie d. Haussäugethiere*, 1885, p. 656.

If the large intestine has been promptly evacuated the next important step is to give only that food which leaves but little irritating waste to pass into the large bowel, such as milk and gruels. In short, it is best to use only boiled or scalded food so as to help the process of digestion as much as possible. It may be necessary to repeat the dose of calomel after a few days. As to this mode of treatment our experience is not sufficient to warrant any positive statements, and it is simply suggested to those who wish to run the risk of treating this disease.

There is another line of preventive and curative treatment which may prove valuable in the future, namely, the feeding of substances with the daily food which, while not injurious to the animal itself, may keep in check the multiplication of the virus in the intestine by an antiseptic action. It is very important, however, to bear in mind that a large number of those medicines which act as disinfectants and antiseptics are likewise injurious or even poisonous to the animal itself. A too abundant feeding of such material, while it may reduce the mortality and lessen the severity of the disease in the sick, is liable to cause injury to liver, kidneys, and other vital organs whereby the nutrition of the animal may be permanently injured. Such medicines, when carelessly given to healthy animals as preventives, may irritate the large bowel sufficiently to reduce its vitality and power of resistance when the disease actually appears. The proper medicine to feed must therefore be selected with care, and we trust that experiments to this effect may be carried on at the Experiment Station at an early date.

There is another line of treatment which demands attention, namely, the introduction of a sufficient amount of some disinfectant into the body to be absorbed, and thus to make the whole body oppose the multiplication of bacteria. Koch tried this method by injecting mercuric chloride into guinea-pigs and afterwards inoculating them with anthrax bacilli. The animals all took the disease and died.

At the laboratory of the Bureau mercuric iodide, a still more powerful disinfectant, was tried upon rabbits. A solution was prepared containing .001 gram mercuric iodide and .002 gram potassic iodide in a cubic centimeter. Of this .5 cubic centimeter was injected beneath the skin of the back of four rabbits (Nos. 1, 2, 3, and 4) for eight successive days. On the third day Nos. 1, 2, and 3, and a fresh rabbit (check), No. 5, received hypodermically into the inner surface of the thigh ¼ cubic centimeter of liquid containing .000001 cubic centimeter of a beef-infusion culture of hog cholera bacteria one day old. All the inoculated rabbits died, the dates being given in the appended table. Rabbit No. 4, which had received the iodide only, to observe any poisonous effect, remained well. The lesions were those of hog cholera and the specific bacteria were present in the spleen. The total amount of the iodide given was .004 gram, about one-sixteenth grain.

Rabbit No. (weighing each about 2 pounds)—	.0005 gram mercuric iodide daily.	Inoculated with .000001 c. c. liquid-culture hog-cholera bacteria.	Remarks.
1	June 22 to 29, inclusive ...	June 24	Died June 30.
2	......do	....do	Died July 3.
3	......do	....do	Died July 6.
4	......do	....	
5	....	June 24	Died July 3.

At the same time healthy pigs were fed with the same substance in minute doses to observe any toxic effect that might appear. These experiments were likewise interrupted in their application by the disappearance of the disease at the beginning of the year. While we therefore recommend, in general, the use of a purgative, such as calomel, in the beginning of the disease, and careful feeding subsequently, we have as yet no actual experimental evidence that such treatment will be of any avail, owing to the frequent interruptions of the work.

HOG CHOLERA IN SWEDEN AND DENMARK.

In the fall of 1887 a disease closely resembling hog cholera appeared in Sweden among swine, which rapidly spread from place to place, showing itself very fatal, and causing alarm and consternation among the agricultural population. The disease invaded the territory of Denmark, where stringent measures were adopted to prevent its further spread. The following communication, received by the Department of State from our consul at Copenhagen and kindly forwarded, may serve to illustrate the measures employed by the authorities to check the epizootic. After giving briefly the symptoms of the disease and the lesions caused thereby, Mr. H. B. Ryder continues as follows:

The very prompt and stringent measures taken by the Danish Government, it is to be hoped, will be the means of localizing as well as of effectually stamping out this malignant pest. For example, circulars have been sent from the home department to all the sheriffs throughout the Kingdom, instructing them to make publicly known that all persons who, within the last two months, may have purchased hogs or young pigs from Copenhagen or in its vicinity should immediately give notice thereof so that their entire herds might be submitted to veterinary inspection. Furthermore, an ordinance has been issued strictly prohibiting all transport of live hogs or young pigs from one district to the other, and that no removal of the animals shall be made from their present dwellings, excepting by special permission for the purpose of immediate slaughter; and, lastly, power has been given to all the police authorities, on any suspicion of disease, to order the immediate slaughter of the animals, and a *post-mortem* examination of the carcass to be made by the veterinary officials; and on the appearance of the disease in any locality under their jurisdiction to order the immediate slaughter of a part or the entire herd as may be deemed necessary.

It is thus to be hoped that by these measures further spread of the disease may be arrested. It is, however, much to be feared that, in addition to the losses entailed upon the Kingdom in the destruction of animals in the course of the disease, the sorely tried farmers in these days of agricultural depression will also be subjected to material loss in a diminished sale to foreign countries of their swine products. An order has already been issued by the German Federal Council prohibiting all importation into the German Empire of swine, pork, and sausages from Sweden, Norway, and Denmark, which will be most seriously felt by the agricultural interests, as the exports of live hogs and young pigs are almost entirely directed to Germany, whilst the exports of pork and hams are mainly forwarded to Great Britain, as will be seen by the following tables, namely:

Live hogs and pigs to—	1881-'85.*	1885.*	Pork and hams to—	1881-'85.*	1885.*
Germany..........head..	276,166	192,273	Great Britain...pounds..	12,550,000	20,240,000
Norway............do...	6,844	4,704	Germany.........do....	2,930,000	7,180,000
Great Britain......do...	2,895	128	Sweden...........do....	3,970,000	3,030,000
Holland...........do...	1,243	....	Norway..........do....	1,200,000	700,000

*Average.

From the foregoing figures full evidence is afforded that whilst the exports of live stock have met with considerable decline in the latter years, a great increase

has taken place in the exports of swine products, due to the large number of slaughter and salting establishments which have been erected in this country for the development of the pork, bacon, and ham trade with England, and thus the loss to the agricultural interests it is to be hoped will not be quite so severely felt as would have been the case in former years under similar unfortunate conditions, and it is scarcely to be feared that England will likewise place obstacles in the way of the free imports of the products into her ports; for inasmuch as the imports of swine into Great Britain from this country have for some time only been admitted in slaughtered condition, and setting apart the facts that swine in mature stage for slaughter are far less exposed to this disease than young pigs, there will be found at the same time, under the close inspection which has been introduced throughout the Kingdom, and the energetic steps taken by the authorities in all cases of suspicion, an almost certain probability that no pork from a diseased animal can possibly be exported. The sale of swine products for home consumption plays likewise a very important part; and it is here again to be feared that restricted sales will be sensibly felt until the temporary scare in partaking of swine flesh has had time to subside.

In order that the energetic measures taken by the Government for the stamping out of the plague may be crowned with full success it will be necessary that the agriculturists should give at the same time a loyal support to the issued instructions, and work hand in hand with the authorities. He who may delay in reporting or may attempt to conceal any disease or suspicion of disease that may show itself at his place will simply be committing a crime against the class to which he belongs; and honesty in this as well as in other cases will be found the best policy; for whereas he who reports the breaking out of disease amongst his flock will receive two-thirds of the value of the slaughtered diseased animals, and full compensation for the slaughtered sound ones, the dishonest party will incur not only risk of confiscation of the diseased meat offered by him for sale, but will also render himself liable to heavy fines. The closing of Germany to the importation of these products undoubtedly can not fail to entail severe loss upon the agricultural classes; but if success can only attend the stringent measures adopted for preventing the further spread of the disease, it must be hoped the prohibition will be of short duration, and that agricultural interests will soon recover from the blow; but should the devastating plague on the other hand spread over the whole Kingdom, it will be nothing short of a national calamity, the destructive effects of which will long be felt, as will easily be understood from the following table of the number of hogs and young pigs to be found in the Kingdom under census of 1881, viz:

	Hogs.	Young pigs.
In the islands .... head..	285,317	392,884
In Jutland .... do....	242,100	334,707
Total.. .... do....	527,417	727,591

Great responsibility will thus rest not only upon the veterinary and police authorities, but also upon the agriculturists, in devoting all possible energy in their mutual exertions to prevent the further spread of this dreaded evil.

The disease is supposed to have been introduced into Sweden by boars imported from England for breeding purposes. Thence it was carried to Denmark,* in which country it first appeared on the dumping grounds near Copenhagen, on which numbers of swill-fed pigs were kept.

Chiefly young pigs up to the age of four months were attacked, the period of incubation lasting from five to twenty days. The infected animals refused food and were at first constipated. Later on diarrhea set in, characterized by the discharge of yellow putrid masses, frequently mixed with blood. The temperature often rose to 105° and 107.5° F. The animals were indifferent to surroundings. Tail and head drooping. Conjunctiva reddened, frequently glued together with dried-up mucus. Respiration in many cases quickened and labored. Occasionally a muco-purulent discharge from the nose. Not infrequently reddening in patches

* Schütz: *Die Schweinepest in Dänemark, Arch. f. wiss. u. prakt. Thierheilkunde,* XIV, 1888, p. 376.

was observed on the ears, snout, abdomen, about the anus and inner sides of thighs. The animals became very weak; posterior part of body swayed in moving about. They concealed themselves in the bedding, and finally were unable to rise. Death followed insensibility and convulsions.

A characteristic sign of this plague were diphtheritic changes on the apex, sides, and under surface of the tongue, as well as on the mucous membrane of the cheeks, hard and soft palate, and the tonsils. On these parts grayish-white or yellowish opaque patches appeared, which were sharply defined, and were converted later into ulcers by removal of the slough.

In one herd the teats of several sows were affected with dark-gray, sloughing sores, with inflammation of the udders. These were infected from the diphtheritic sores in the mouths of the sucking pigs. In Denmark the disease was first recognized in this way. The acute disease lasted from five to eight days, but sometimes death occurred sooner than this.

The disease appeared in Denmark in September. In December the plague took on a more chronic character and became less infectious. The infected animals frequently showed no indications of disease, only they were smaller and thinner than others of the same age. There was occasionally coughing and diarrhea. Some recovered; others perished by a gradual wasting away. The *post-mortem* appearances were very characteristic. The large intestine was attacked in every animal, and in acute cases the small intestine and stomach likewise were reddened and swollen, and the surface in part covered with a thin layer of a grayish-white or grayish-yellow soft mass, which consisted of fibrin. This same layer was very thick in the large intestine, easily lifted away *in toto* in some places; in others the attachment was firmer (diphtheritic). In other acute cases there was simply reddening and swelling of the mucosa of stomach and small intestine, and diphtheritic changes in the large intestine, the fibrinous exudate being absent. Moreover, the follicles, Peyer's patches, and mesenteric glands were always tumefied.

The seat of the diphtheritic process was the whole large intestine, more especially the cæcum. The follicles and Peyer's patches were nearly always affected. The ulcers appeared when the slough had come away. In the place of the follicles button-like sloughs were formed, which gradually invaded the whole thickness of the wall, spread laterally, and ran together into larger patches. The wall, thus converted into a cheesy mass, was frequently one-fifth to two-fifths of an inch thick, on the surface irregular, colored yellow, brown, or green. Hemorrhage, due to the ulceration, was observed in one case.

In many animals the lungs were healthy. In some a muco-purulent catarrh of the bronchi was present, which caused atelectasis in one or more places with young and weak animals. Usually the ventral and anterior lobes were affected. In the diseased lobes homogeneous, cheesy masses appeared later, sometimes as large as a walnut. These masses led subsequently to inflammation and adhesion of the pleura to chest-wall, pericardium, etc. The spleen was not changed as a rule. In a few cases only it was somewhat enlarged, soft, dark red.

When we compare these lesions with those found in our country we observe the absence of hemorrhagic lesions and enlargement of the spleen and the presence of more marked exudative and diphtheritic changes in the large intestine. In numerous sections of ulcerative changes we have not observed any relation between these and the follicles. The lung lesions correspond closely. Whether they are due to the disease or not must be left undecided. We have frequently seen caseous changes in the lungs of animals free from infection, and they are, perhaps, due to collapse, broncho-pneumonia, and subsequent interference of the circulation rather than to the direct action of bacteria.

The specific bacteria which are the cause of the swine disease are described briefly by Selander,* and according to his description they closely resemble hog cholera bacteria in form, motility, growth in gelatine, and appearance in tissue. Their growth on potato is said to resemble that of the bacilli of typhoid fever in man, and thus to differ from hog cholera bacilli.† Their effects on the lower animals

* *Centralblatt f. Bakteriologie*, etc., 1888, i, 362.

† The chemical reaction of the potato surface, which varies considerably, frequently determines the nature of the growth. Cultures of hog cholera bacilli on potato scarcely visible may be made very vigorous by making the potato alkaline.

correspond also, although the descriptions are too brief for careful comparison. There is no mention of the coagulation necrosis, found constantly in the liver of rabbits inoculated with American hog cholera.

In the beginning of the present year (1888), Dr. John Lundgren, professor of veterinary medicine in the University of Stockholm, was sent by the Swedish Government to study swine diseases in this country. He spent several weeks in the laboratory of the Bureau, studying the bacilli of hog cholera. A culture of the swine pest bacilli from the Swedish epizootic was at that time subjected to a careful examination.

In gelatine the swine pest germ grows in general like hog cholera bacilli. On the surface of the gelatine the growth is very thin, translucent, of a pearly luster, and spreads more rapidly than the hog cholera growth. On *agar-agar* the growth is more abundant and more rapid. Beef infusion, with or without peptone, is converted into a very turbid liquid within twenty-four hours at 95° F., while hog cholera cultures are barely opalescent at that time, and remain so. Two mice were inoculated from an *agar-agar* culture of the Swedish germ under the skin of the back. Both were slightly ill next day. On the second day one was found dead. The cultures from it remained sterile. It probably died from some other cause. The second mouse remained well. On a rabbit the effect was equally negative. No rabbit survives inoculation with hog cholera bacteria.

The effect of both germs on pigs was next tried. Two Erlenmeyer flasks, containing each about 300 cubic centimeters (two-fifths pint) of sterile bouillon, were inoculated, one with the American, the other with the Swedish germ, and placed in the thermostat at 95° F. On the following day both flasks were clouded; the Swedish culture was covered by an iridescent, very thin membrane. A comparative microscopic examination showed the Swedish bacteria to be nearly twice as large as the American; their movement was far less active than that of the latter.

On the same day two pigs, starved for about twenty-four hours, were fed with these cultures by drenching, *i. e.*, the liquid was poured into the mouth so that none was lost. The pig fed with the Swedish culture showed no signs of disease at any time after. The other pig, on the fourth day, had a very liquid diarrhea, and was found dead the next morning. On examination, the spleen was found gorged with blood, but only slightly enlarged. Mesenteric glands enlarged and reddened. Stomach and ileum intensely inflamed (enteritis); grayish masses (diphtheritic) attached in patches. The ileum was invaginated and projected for 2½ inches into the cæcum; mucosa of this portion necrosed; walls infiltrated, thickened, and ecchymosed. In the cæcum the mucosa was covered by a very thin slough. In the colon the membrane was deeply reddened, covered by a catarrhal exudate and dotted with numerous very minute ulcers. Heart and lungs normal. Roll cultures in gelatine, as well as liquid cultures from the spleen, contained only hog cholera bacteria. The invagination was very likely the result of the violent inflammation.

These comparative experiments show that the two germs, though very much alike in appearance, were quite different with reference to their pathogenic effect. Professor Lundgren was inclined to the opinion that he had taken the wrong culture on leaving his native country. It may also not be improbable that this was the true germ attenuated on the way hither. As no communication has been re-

ceived from him since his visit here, the question must remain an open one.

FRANCE.

During the summer of 1887 a disease was introduced into the vicinity of Marseilles by swine from Africa, which developed into an epizootic of a very fatal character. It caused great losses in the south of France, and at the time scientific men were sent from Paris by the Government to investigate the cause and suggest a remedy if possible. According to Rietsch, Jobert, and Martinand * the disease is chiefly restricted to the intestinal tract, lasting from ten to twelve days after the first symptoms have appeared. Occasionally it may last but three or four days, or be prolonged to several weeks, but it is quite invariably fatal. Sometimes there is diarrhea, sometimes constipation; the fever is not constant, the cough very rarely heard. The hind limbs are weak, the walk tottering. Appetite often persists to the end. The skin may become reddened in spots, especially on the limbs and ears. Pigs over a year old are much less susceptible.

At the autopsy the lungs, liver, kidneys, and spleen are usually found unchanged, and the disease limited to the digestive tract. The stomach and the small intestine near the valve are ulcerated. Ulcers are present in the large intestine on the valve, in the cæcum and colon. They may measure 3 to 4 inches in diameter. In animals affected with a chronic form of disease there may be ulcers on the inferior surface of the tongue and on the inner aspect of the lips. The internal organs are free from bacteria. But from the contents of the intestine and the ulcers a motile bacillus was obtained. Mice are killed in ten days after subcutaneous inoculation with cultures of this organism. Of ten adult mice fed with cultures two died in fifteen days. Of ten young mice all died when fed, the first in thirty hours; the others in fifteen to twenty-three days. Rabbits are but slightly susceptible. A young guinea-pig fed with cultures died twenty-two days later. The intestine showed characteristic ulcers.

Dr. Rietsch very kindly sent to the Bureau a culture of the germ which he found. It was compared with the American hog cholera germ and the following characters determined:

The motile bacilli of the same form as hog cholera bacilli, but larger, grow far more abundantly and rapidly in beef infusion. A thin membrane and a copious deposit are produced in a few days, and the liquid becomes very turbid. On gelatine the colonies differ slightly from those of hog cholera. The surface colonies spread in thin iridescent patches from 2 to 5 millimeters in diameter. In tube cultures the isolated deep colonies grow to about one-third millimeter in diameter. On the surface the growth is rapid and spreads over the greater part of that which is available. The patch produced is whitish, uniform in thickness, very irregular in outline, inclosing round spaces of uncovered gelatine. In the bottom of the tube a few air bubbles appear. On potato the growth forms a glistening, pale yellow patch at the ordinary temperature.

Thus they resemble the Swedish germs very closely, differing by so much from hog cholera bacilli. A rabbit and two mice inoculated with the Marseilles germ remained well. Equally so a pig fed with 400 cubic centimeters (four-fifths pint) of a beef-infusion peptone culture.

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* *Compt. Rend. Acad. Sciences*, Jan. 28, 1888.

So far as our examination of the Swedish and Marseilles cultures have gone, it has shown them identical both as regards their positive and negative characters. They differ from hog cholera bacteria enough to constitute at least a variety. But the investigations of French savants of this Marseilles epizootic differ somewhat as to the cause.

Cornil and Chantemesse * described a disease discovered among swine in the vicinity of Paris which they consider identical with the German *Schweineseuche* and our swine plague. Subsequent experiments † to determine the biological properties of the bacteria causing the disease show that they are not dealing with the true swine-plague germ (certainly not as we have observed it in this country), but with one resembling more nearly hog cholera. Their researches concerning vaccination are reported to have been successful on rabbits and guinea-pigs, but since that time nothing has been published concern- experiments on pigs.

While Rietsch and Jobert ‡ come to the conclusion that the Marseilles disease resembles hog cholera closely, Cornil and Chantemesse regard it identical with swine plague, although the germ they describe is not identical with the swine plague germ, as studied in Germany and in the United States.§

It is interesting, in this connection, to trace the march of infection in the south of France, as reported to the French Academy by Fouque,‖ as an excellent illustration of the ways by which infectious diseases may be scattered broadcast over a country:

> The disease did not, as was supposed, appear in Marseilles toward the end of June, but in the month of April, and I have been able to locate three entirely distinct centers of the outbreak due to the same cause—the introduction of African swine. These three centers are: The village of Caillols, midway between Aubagne and Marseilles; the village of Sainte Marthe, 6 kilometers northeast of Marseilles, and the herds of the Mediterranean distilleries.
>
> (1) From the 10th to the 15th of April a breeder of Caillols received a drove of black swine from the province of Orans (Algiers). From the first week some cases of pneumonia showed themselves among the last animals. The disease gained rapidly, causing many deaths. The survivors were sold on the 4th of May following.
>
> On the 8th of June the same piggeries were restocked, partly with African and partly with Russian swine. Towards the end of the month there were cases of pneumonia.¶ The Russian swine resisted less than the others. August 16 the piggery was again emptied. Finally, during September, the third attempt was made, exclusively with African swine. This also proved a failure. The survivors were sold in October.
>
> During this time the disease reached the neighboring piggeries, stocked with a mixed Marseilles breed. The breeders of Caillols, alarmed by the ravages of an epizootic, the nature and cause of which they did not know, decided to sell out at any price. The neighboring localities, Saint Marcel, Saint Loup, San Juan-du-Désert, etc., were successively infected. Infection was spread by the sales and exchanges of sick and suspected animals, by means of transportation (carts often used in common by several establishments soiled by the dejections of the sick, and

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* *Compt. Rend. Acad. Sciences*, 1887, cv, p. 1281.

† L. c., 1888., cvi, p. 612.

‡ L. c., p. 1096.

§ In a recent review of the reports of the Bureau of Animal Industry by Duclaux (Annales de l'Institut Pasteur, July, 1888) the reviewer regards this disease as identical with hog cholera, and states that Cornil and Chantemesse had at first overlooked the motility of the germ they were studying, a rather unpardonable bit of carelessness.

‖ L. c., p. 670.

¶ The writer calls the disease infectious pneumonia for want of a better term, although Rietsch distinctly states the intestinal nature of the malady. Fouque was no doubt led astray by the early misleading notices of Cornil and Chantemesse.

afterward used to transport healthy animals and their feed), and also by the lateral canal of Huveaune, which receives at certain points running water coming from the grounds on which the piggeries are located.

At the beginning of September all the valley of Huveaune, from Aubagne as far as Marseilles, was infected. Diseased pigs from this region we meet again in the market of Aubagne, at the fair of September 21, and which became later on the most active agents in spreading the disease in the departments.

(2) Toward the middle of the month of August the disease appeared in a piggery in Sainte Marthe, stocked exclusively with African swine. These animals came directly from Oran without coming in contact with any other of their species. Several days later one of the largest breeders in that vicinity, who for three months had not brought a single pig to his establishment, and whose piggery was at least 600 feet away from the preceding one, sustained a considerable loss, especially among the pigs of 130 to 175 pounds.

(3) Finally, on the 25th of June, sick pigs came from Oran to the piggeries of the Mediterranean distilleries. There were very soon a number of victims of pneumonia, not only in the distilleries but also in the neighborhood, where there were from 4,000 to 5,000 in a comparatively small territory. A great many of the sick died; the others were quickly sent to different cities to be delivered to the butchers. I have traced the history of six sows which were sold from the midst of infection to Estaque, thence they passed through the commune Rove and arrived in August at Gignac, where they introduced the disease. By an odd coincidence, some sick pigs from the same locality were taken to the fair at Aubagne and bought by a breeder of Gignac.

The fair at Aubagne, on September 21, marked the most important phase in the progress of contagious pneumonia; during the first fortnight in October there was a veritable explosion of the disease, which up to this time had been scarcely known.

The importation of the disease by animals bought at the fair of Aubagne can be traced with the greatest precision in the suburbs south and north of Marseilles, also as far as Gardanne, in the communes of Septemes, Vitrolles, Pennes, etc., to Gignac, as mentioned above, even into the neighboring departments, which continued with the others to receive consignments of Marseilles swine. It is also necessary to mention Puget, Ville et Grasse among the localities infected.

In the beginning of December, 153 swine were shipped from Marseilles to Nice; nearly all died in a few days. From that time cases appeared among the native pigs.

On December 22, another lot of 133 pigs were shipped; 33 were destined for Nice, and 100 for Italy. These last were sold on the 24th, in the market of Vintimille; nearly all died very soon.

For several years Marseilles annually exported to Spain, and especially to Barcelona, a great number of pigs. Contagious pneumonia had been causing losses there for several months, even, it is said, at Majorka in the Balearic Islands. The Spanish breeders, believing the outbreak of the disease with them was attributable to the importation of French pork, obtained from the authorities the permission to impose a quarantine of six days at Port Bouc on swine from Marseilles, to begin on the 1st of the following February. This measure has not been enforced up to the present day.

From what has preceded I believe I can conclude that the epizoötic of contagious pneumonia which has raged during the year 1887 in the interior of France, and which, at this time, continues its ravages there, is of African origin. It has been introduced by Algerian swine which came from the province of Oran. This disease has made 20,000 victims in several months in the province of Bouches-du-Rhone.

Pigs, and especially those from three to nine months old, are oftenest attacked; larger pigs appear less susceptible. The Marseilles breed, English (Yorkshire and Berkshire), and the Russian swine are more susceptible than the African swine.

Two months ago about 50 pigs two to three months old, coming from Cazeres and Le Fousseret, in the arrondissement of Muret, were used to stock a farm in Gignac. These pigs, placed in the pens which had contained sick ones, and which had only been very imperfectly disinfected, remained in good health, while more than a hundred cases of contagious pneumonia appeared around them in the same piggery. Afterwards more than 2,000 Gascon swine were imported by the single commune of Gignac. Up to the present time the disease has not re-appeared. Are we here confronted by a new example of natural immunity comparable to that noticed long ago by Chauveau in Algerian sheep in regard to anthrax?

Taking into consideration what we know now of these epizootics and enzootics of swine diseases in foreign countries, we are forced to the conclusion that the disease in Sweden, Denmark, and France is

closely related to, if not identical with, hog cholera as it is found in our own country.

EXPERIMENTS ON THE ATTENUATION OF HOG CHOLERA BACILLI BY HEAT.

Heat has been used by Pasteur in the attenuation of anthrax virus by exposing cultures of anthrax bacilli to a temperature of 42°–43° C. continuously for a certain number of days. Cultures kept in a thermostat at this temperature for about thirty-one days were so attenuated that they were incapable of destroying animals larger than very young mice. Kept in the same conditions for only twelve days, inoculation failed to destroy adult guinea pigs.* The former culture was denominated the first, the latter the second vaccine. To make sheep immune they were inoculated subcutaneously with the first vaccine and twelve days later with the second vaccine. Subsequent inoculation with strong virus had no effect upon the vaccinated animals, although it was quite invariably fatal to those which had not been so treated.

Although Pasteur's discovery must be considered a scientific event of great importance, its practical application is by no means a perfect success. Experiments conducted by Koch, Gaffky, and Löffler, in Berlin, have shown that the process of attenuation does not always go on uniformly, and that the strength of the vaccine can not always be relied upon. A few animals may die as a result of the first or second inoculation. This fact induced the last international congress of hygiene at Vienna to adopt the resolution that anthrax vaccination should not be practiced upon sheep in any locality unless the disease causes a loss of 2 to 3 per cent. annually. It was also shown in the experiments at Berlin that immunity after vaccination is not absolutely perfect when the virus is introduced with the food. This is perhaps the most common way in which infection takes place.

The results obtained by Pasteur are sufficiently valuable to make it at least desirable to try heat attenuation for other bacterial organisms, although it does not follow by any means that the same process will suffice for all or even a small number of disease germs, for these differ among one another very widely.

Kitt† has tried heat in the attenuation of the virus of Black Quarter in Germany by exposing the diseased muscular tissue, which had been thoroughly dried in the air and ground to a fine powder, to the steam of boiling water at 100° C. for four, five, and six hours continuously. The spores of the bacilli of this disease were sufficiently attenuated after a six hours' exposure so that sheep inoculated with the powder in certain doses remained well after inoculation with strong virus. The reaction after the vaccinal inoculation was very slight. Hog cholera virus is destroyed by a fifteen to twenty minutes' exposure in a water bath at 58° C. A momentary contact with boiling water is sufficient to destroy it, so that Kitt's method is not applicable to it but only to bacteria which form spores.

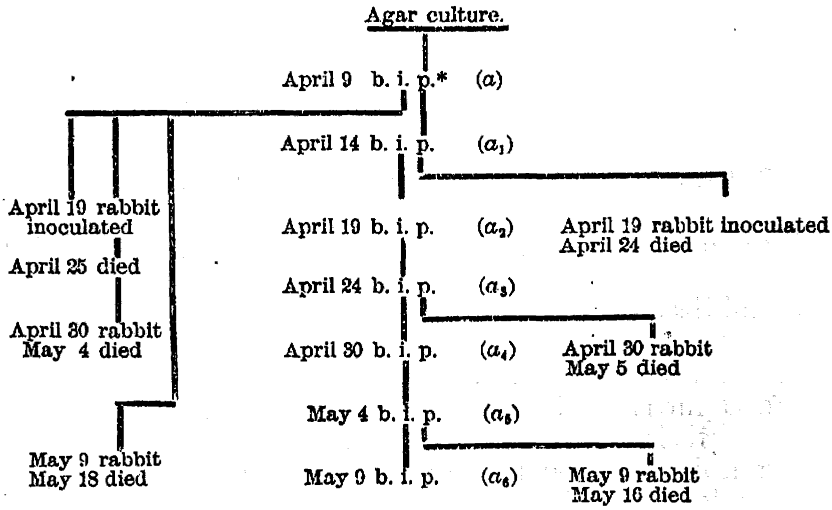
The following experiments were undertaken with a view to test the method of Pasteur on hog cholera bacilli, and to obtain, if possible, a vaccine similar to that employed in the prevention of anthrax. Although only a preliminary step has been taken in this matter, and

* *Compt. Rend. Acad. des Sciences*, March 21, 1881.
† *Centralbl. f. Bakteriologie u. Parasitenkunde*, 1888, i, 571.

the promise of favorable results is not flattering, we consider it best to publish the results thus far obtained.

The first step in the process was to obtain, if possible, a cultivation which should prove harmless to rabbits. This was to be accomplished by placing tubes in a thermostat kept at a certain fixed temperature as nearly as possible, and inoculating rabbits from time to time to determine any diminution in the pathogenic activity.

April 9, 1888.—Four Salmon tubes of beef-infusion peptone were inoculated from an *agar-agar* culture of hog cholera bacilli two weeks old, and placed in a d'Arsonval thermostat, the internal temperature of which registered between 42° and 43° C. Two series of inoculations were made on rabbits, one from one of the original liquid cultures at different intervals, the other from a culture renewed at the end of every five days by inoculating a fresh tube. The result is most easily understood by examining the following table:



The first inoculations were made April 19, with culture a, which had been in the thermostat ten days, and culture a_1, which had been freshly made on April 14. Both rabbits received about $\frac{1}{8}$ cubic centimeter of the culture liquid hypodermically. Rabbit a_1 died in five days with extensive coagulation necrosis in liver and enlarged spleen. Rabbit a died on the following day with the same lesions. In both hog cholera bacilli were very numerous on cover-glass prepartions of spleen, and obtained pure in cultures. The same results were obtained in all subsequent cases so that no further mention need be made of this.

Two rabbits were inoculated in the same way April 30, one from the original culture a, the other from a_3. Both died May 4 and 5, respectively. Lesions the same as with the first pair.

Two rabbits were inoculated May 9, one from the culture a, now thirty days old, the other from a_5, the fifth renewal of a. Both rabbits died on the 7th and the 9th day, respectively. The lesions were practically the same, with the addition of slight hemorrhagic lesions in the intestinal tract. The period of the disease was slightly prolonged.

The result was not very satisfactory, therefore, for if any attenuation was going on its final attainment would demand too long a period of time. The experiment was therefore stopped and another undertaken. The temperature of the thermostat was raised to 45° C. to hasten the process of attenuation.

* Beef infusion plus 1 per cent. peptone.

April 23 agar culture.

May 12 b. i. p. (*b*)

May 22 rabbit inoculated. May 29 died

May 17 b. i. p. (b_1)

May 22 b. i. p. (b_2)

It was found that cultures inoculated from *b* failed to develop at the assigned temperature, so that this experiment was not continued any farther. It deserves to be mentioned, however, that a rabbit inoculated from the original culture which had been kept at 45° C. for ten days died seven days after inoculation with enlarged spleen and coagulation necrosis in liver.

A temperature of 43½–44° C. was next chosen, and the experiment conducted in the same manner, as the appended table will show:

May 16 agar culture.

May 29 b. i. p. (*a*) (43.5°–44° C.)

June 8 rabbit
June 14 dead.

June 18 rabbit

June 23 dead

June 28 rabbit
remains alive
Culture dead

July 10 rabbit
(remains alive)

June 4 b. i. p. (a_1)

June 8 rabbit
June 15 dead

June 8 b. i. p. (fails to grow)

June 13 b. i. p. (a_2)

June 18 rabbit

June 24 dead.

June 18 b. i. p. (a_3)

June 28 rabbit
July 5 dead

June 28 guinea-pig
July 10 dead

June 23 b. i. p. (a_4) (supposed impure, but found pure.)

June 28 b. i. p. (a_4)

July 10 rabbit
(remains alive)

July 10 b. i. p. (a_5)
(culture dead)

May 16 agar culture

May 29 b. i. p. (b) (43½°–44° C.)

July 14 placed at 30°–33° C.)

July 25 rabbit
July 30 dead

August 4 rabbit
(remains well)

August 4 b. i. p.
(sterile)

The rabbits inoculated from the original culture, after remaining at the temperature of 43.5°–44° C. for ten and twenty days, died from the inoculation disease, but those inoculated from the same tube after thirty and forty-three days remained permanently well. This was not due to an attenuation of the culture but to its death. Turning to the series of rabbits inoculated from the cultures renewed every five or ten days those receiving culture liquid ten, twenty, and thirty days old died from the inoculation disease, while one inoculated after forty-three days remained alive, because the culture was dead, *i. e.*, it failed to fertilize fresh tubes after repeated inoculation. An adult guinea-pig, inoculated from the same culture material thirty days old, died in 12 days as a result of the infection. In this case only a few drops has been injected. This experiment demonstrates that in general the pathogenic power of hog cholera bacilli is only destroyed by the death of the organisms themselves. This is a very important fact. It will be remembered that in the attenuation of anthrax bacilli, their virulence was gradually diminished and a time was reached when they failed to kill all but mice, while they still retained the power of multiplying in nutritive liquids. In the above experiments even guinea-pigs, which are less susceptible to this disease than rabbits, died twelve days before the culture was found dead. The latter may have been dead some days before this, for no tests were made meanwhile.

This fact has an important bearing upon the nature of the pathogenic activity of hog cholera bacilli. It shows that there are two elements involved, (1) the ptomaine action of the organism; (2) their mechanical effect. That there is a ptomaine action of these bacilli has been conclusively proved in the experiments of the Bureau made upon pigeons several years ago. But this ptomaine action is evidently secondary to the mechanical effect of the bacilli in forming plugs or thrombi in the blood vessels and thus causing destruction of tissue by impeding the circulation. This tendency to act mechanically is not lost as long as the bacilli are alive, as shown by their fatal effect on rabbits and guinea-pigs shortly before they themselves are destroyed.

At the temperature employed (43.5°–44° C.) the original bouillon-peptone culture *a* died between the twentieth and the thirtieth day after the beginning of the exposure. The culture from this, renewed at the end of every fifth or tenth day, died between the thirtieth and forty-second day. Another culture, *b* (see table), which had been removed from the thermostat after the forty-sixth day and kept at the temperature of the laboratory (about 30°–33° C. during July), was still fatal to a rabbit on the fifty-seventh day. Another rabbit inoculated ten days later remained well, and a fresh culture made at the same time remained sterile, showing that the apparent immunity of the rabbit was due to the death of the bacilli injected. This experiment also shows pretty conclusively that the pathogenic power of these specific organisms expires only with their life and not long before.

It is evident from our own experiments and more recent ones made in France and Germany, and conducted on the same lines, that the amount of immunity which we may expect to gain from preventive inoculation will depend on the quantity of ptomaines produced by the specific microbes, *i. e.*, upon their poisonous nature. In other words, our success will depend upon the relation borne by the ptomaine to the disease process. If this factor is very great it is highly

probable that preventive inoculation either with ptomaines or with attenuated cultures will be successful. But if there is, in addition, a mechanical element which may overshadow in importance the ptomaine element, the problem is not only complicated, but may fail.

There are two other points in connection with these experiments which demand attention. One is the variation in the length of life of the different cultures exposed to the same conditions. This would be a serious hindrance in obtaining vaccinal cultures of uniform strength should this method ever prove successful.

There was a noticeable change in the appearance of the serial cultures after a sojourn in the thermostat. There was a tendency to multiply rather more abundantly, to grow in minute flakes, and to rise to the surface to form a thin, unbroken membrane. The motility was somewhat impaired after a time. These changes gave rise to the suspicion of impurities, but tests on gelatine plates showed that the suspicion was unfounded. These experiments will be continued on rabbits and pigs under similar conditions to determine whether any immunity can be produced by this method.

INVESTIGATIONS OF AN OUTBREAK OF INFECTIOUS SWINE DISEASES NEAR BALTIMORE, MD., SEPTEMBER, 1888.

The practical difficulties in connection with the solution of the problem of infectious swine diseases has been pointed out, in the annual report of the Department of Agriculture for 1887, to be due to the existence of two diseases producing lesions of the intestinal tract which shade into one another and are therefore not distinguishable by the naked eye. The presence of the specific microbe seems to be the only final test. As a rule, however, swine plague is primarily a disease of the lungs, secondarily of the digestive tract, while we have invariably found hog cholera a disease of the intestinal tract and more particularly of the large intestine, with unimportant lesions of the lungs very likely not due directly to the hog cholera virus. This difference may often serve as a guide when bacteriological examination can not be made, but even this is frequently misleading. The existence of extensive lung disease as the result of the polar-stained swine plague organism does not exclude the simultaneous existence of hog cholera. It is not an uncommon thing to find the lesions of both diseases as well as the microbes which produce them in the same animal. The following cases illustrate this condition of things very well. Several pigs from two separate herds near the city of Baltimore, Md., which were affected with some infectious malady were examined and both hog cholera and swine plague germs were found in the same animal. One of these animals was transferred to the experimental station at Washington, and there gave rise to an epizootic of both diseases. The swine plague soon gave way to the hog cholera, however, and later on lung disease was but a secondary element in the disease, hog cholera persisting with variable severity for months after.

In the herd which contained the following pigs the disease broke out four weeks ago and was very likely due to the introduction of infected swine by purchase.

September 10, 1888.—A small shoat (No. 1) from this herd was seemingly very ill. Flanks tucked in, hind portion of body swaying and tottering when the animal moved. It was killed by cutting its throat.

In the lungs was found broncho-pneumonia, localized chiefly in the ventral and cephalic lobes. In the larger bronchi lung worms were present. Superficial inguinal as well as the mesenteric glands were swollen and slightly congested. The spleen was but moderately enlarged. In the upper portion of colon were two small superficial ulcers. The mucosa was otherwise intact as far as the rectum. In the latter situation it was covered with a peculiar grayish deposit, soft, almost like lard, without tenacity. It was arranged as isolated round patches, from one-eighth to one-fourth inch across and about one-sixteenth inch thick; the mucous membrane for a distance of 18 inches from the anus being thickly covered with them. They are easily removed and leave a slight depression in the mucosa without apparently any loss of substance. This exudate is made up of degenerated cells, probably epithelial in origin, but they are too far broken down to allow any closer examination. Immense numbers of bacteria in this deposit of two kinds chiefly; a rather large oval bacillus, with periphery more deeply stained and a very slender rod.

From this exudate a rabbit was inoculated (September 11) by stirring it up in sterile water thoroughly and injecting some of the liquid under the skin of one thigh. The rabbit was dead on the sixth day. There was an extensive sanguinolent staining of the subcutis of the entire abdomen, and of a part of the thorax and thighs. Groups of petecchiæ on the cæcum. Some of the coils of intestine lightly glued to abdominal wall. Spleen small. The peritoneal surface is covered with minute cocci; the same are present in the blood. *Agar* cultures from the peritoneal surface and heart's blood contained the same organisms. Although polar staining was not manifest, there was no doubt that the microbe was the non-motile swine-plague germ.

At the same time a rabbit was inoculated in the same way with lung tissue. This animal died in two days. The subcutis of inoculated thigh slightly blood-stained. The superficial muscular fiber of a grayish homogeneous appearance. The fascia and muscles of the contiguous portion of the abdominal wall opaque, infiltrated. On the coils of intestine a few small masses of a whitish exudate. Spleen slightly enlarged; liver very much engorged. No bacteria could be distinctly seen on cover-glass preparations from liver, spleen, and blood. But tubes inoculated from blood and spleen contained on the following day only swine-plague germs. Roll cultures made from the lung tissue of the pig were liquefied completely in a few days.

The examination of the spleen gave quite different results. Although the microscope did not reveal any bacteria on one cover-glass preparation from the spleen, three liquid cultures into which a bit of spleen had been placed contained on the following day actively moving hog cholera bacilli. On the surface of an *agar* culture a considerable number of colonies of the same organism made their appearance. A roll culture made from one of the liquid cultures contained about 300 colonies, non-liquefying, all alike, and resembling in growth hog cholera bacilli.

It was very important to determine the pathogenic character of this bacillus in order to confirm the diagnosis based upon its appearance under the microscope and in cultures.

September 13.—Two mice were inoculated subcutaneously, each with several drops from one of the liquid cultures from which the roll culture had been made. One mouse was dead September 19, with spleen

enlarged, and in it numerous hog cholera bacilli; the second mouse remained apparently well and was killed fifteen days later. Its spleen was enormously enlarged, and it would no doubt have succumbed in a few days. But the following intravenous injection from an *agar* culture which was inoculated from the original spleen *agar* culture is sufficient to set aside all doubt as to the nature of the spleen bacilli:

November 12, 1888.—Pig No. 90, black and white, about five months old. The right crural vein was exposed by raising a triangular flap of skin over it after thoroughly disinfecting the latter with a 1:500 solution of mercuric chloride. Five cubic centimeters of a beef-infusion peptone culture inoculated from an agar culture about a week old was injected into the exposed vein with a hypodermic syringe thoroughly disinfected with 5 per cent. carbolic acid. The liquid culture was two days old when used. Two hours after the inoculation the temperature had risen from 103⅘° F. to 107° F. November 13, there was no swelling, but a slight serous oozing at the place of inoculation. The appetite was good. November 14, at 3 p. m., the temperature was 107⅘°. The animal was disinclined to move, although it came to eat in the morning and evening. November 15, it lay on its side, quietly, with occasional kicking. Found dead at 4 p. m. Autopsy held immediately.

General blush on skin of ventral aspect, snout, and lips. No swelling at the point of inoculation; slight blood extravasation. Spleen enormously enlarged, 14 inches long, two-thirds inch wide, and one-half to 1 inch thick, gorged with dark blood, and friable. Superficial inguinals enlarged, œdematous; on section diffuse pale red spots; cortex congested. Bronchial and renal glands enlarged, partly hemorrhagic; gastric glands hemorrhagic throughout substance. The blood is thick, dark colored, coagulation slight, even after several hours' exposure to the air. Several petecchiæ on epicardium of right auricle. Right side of heart distended with blood. In it a small white clot. Left heart contracted, empty. Lungs normal, excepting one-third of left ventral lobe, which is collapsed. Kidneys enlarged, deeply congested throughout. The surface is thickly dotted with minute deep red points. The papillæ so deeply reddened that any extravasations would not be recognizable. A few petecchiæ in pelvis. Bladder contains about 30 grams of urine tinged with blood. The whole mucosa of stomach is deeply congested. In fundus it is hemorrhagic, with numerous patches of necrosed epithelium one-quarter to one-half inch across. The upper 8 inches of duodenum in the same condition as the fundus of stomach. Numerous red points scattered over mucosa of entire small intestine. In lower ileum a few hemorrhagic points. The mucosa of cæcum and upper colon very slightly congested, but the remaining two-thirds intensely so. Hemorrhage here and there sufficient to stain the feces with blood which were otherwise normal. The mesenteric and meso-colic glands all deeply congested throughout their substance.

Cover-glass preparations from spleen pulp showed a large number of hog cholera bacteria. Cultures from the same revealed the presence of the same organisms only.

September 19.—Pig No. 2, alive in the morning, dead at noon. Examined soon after death. Slight reddening of skin on throat, inside of limbs and pubic region. Spleen very large, engorged, softened. Lymphatic glands generally enlarged but pale, excepting the retroperitoneal glands, the cortex of which is deeply congested. Liver imparts a harsh sensation to the knife. Kidneys normal. *Echinorhynchi* in jejunum attached to ulcerous depressions in the mucosa. Lowest 12 inches of ileum contain several deep ulcers one-fourth to three-fourths inch across. The mucosa of the ileo-cæcal valve is thickened, ulcerated superficially, and indurated beneath. There are several large ulcers near the valve and in the upper colon, from one-half to 1½ inches across. The corresponding serosa inflamed and attached to neighboring organs.

All but the caudal and dorsal half of the principal lobe of each lung solidified. The diseased principal lobe has a bluish red, the other lobes a pale-grayish red color. In the former the infiltration is in the form of minute whitish plugs in a red ground. The latter

on section has a glistening, half-gelatinous aspect. The cut bronchioles exude a milky, purulent fluid.

Bacteriological examination of lungs showed in stained cover-glass preparations a large number of pus cells and polar-stained bacteria, located chiefly around the nuclei of the larger cells and probably imbedded in the now disintegrated cell protoplasm. A few large bacteria present. Of two roll cultures from this grayish lung tissue one was completely liquefied, the other partially so. A rabbit inoculated from the same tissue (grayish) died in four days.

The fascia of the inoculated thigh was much thickened, whitish, the subjacent muscular tissue discolored, pale. Intense peritonitis manifested by a grayish exudate covering large intestine and liver; the serosa of the former was extensively ecchymosed and glued to the ventral abdominal wall. The exudate consisted chiefly of leucocytes and immense numbers of polar-stained swine plague bacteria. These were very scarce in blood. An *agar* culture from the latter contained only swine plague bacteria. A rabbit inoculated at the same time with the red hepatized tissue was ill subsequently, but recovered. It was killed on the sixteenth day. An extensive subcutaneous abscess was found over the abdomen, with necrosis of the skin, which was converted into a dried mass hard as a board. Spleen very slightly enlarged.

From a bit of spleen pulp from the pig, which was engorged, dark, and enlarged, a roll culture was made. About one hundred colonies of hog cholera bacilli developed. Two beef-infusion peptone tubes into which spleen bits were placed contained on the following day hog cholera and butyric bacilli. To test the virulence of the hog cholera bacilli, two or three drops of one liquid culture were injected beneath the skin of two mice September 28. One died prematurely on the following day with enlarged spleen, owing to the extensive invasion of liver and kidneys with coccidia, and consequent degeneration of these organs. The second mouse died in three days with a large number of *tænia* in the dilated duodenum. Both died no doubt from the inoculation, but their death was hastened by the presence of the parasites, making the demonstration unsatisfactory.

Another pig (No. 3) which had been found dead in the morning and undergone considerable decomposition was examined superficially at the same time. The spleen was very much enlarged; lungs normal. The large intestine contained extensive ulcers with localized peritonitis and adhesion to surrounding structures. No bacteriological examination was made.

A third pig from the same herd (No. 19) was taken, while sick, to the Experiment Station of the Bureau in order that fresh pigs might be infected and our study of the disease continued. It was found dead September 24, four days after its arrival. This animal also manifested both diseases, more prominently so than those already described. Both germs were found in its body, the hog cholera bacillus in the spleen, the swine plague coccus in the lungs, as the following notes show:

Autopsy several hours after death. No skin discoloration. Spleen very large, due to blood engorgement. Lymphatic glands of abdomen in general very much enlarged, and slightly congested, excepting those of mesentery. Kidneys normal. Liver slightly cirrhosed, somewhat gritty on section. Mucosa of stomach covered with yellow bile-stained mucus, empty. Small intestine not diseased. In the cæcum and upper 12 inches of colon, about a dozen ulcers, one-half to 1¼ inches across, with a dirty blackish floor. The ulceration has produced inflammation of the serosa and thickening of the wall.

Lungs extensively diseased. Of the right, the caudal half of the cephalic, the entire ventral, and the cephalic (anterior) third of the principal lobe hepatized. Of the left lung the same regions, including the azygos lobe, are in the same condition. Over these diseased lobes the pleura is covered with a translucent, very thin exudate,

either in the form of dots or a mesh-work. Only a little of the adjacent normal lung tissue has the pleura roughened. The exudate is made up of leucocytes and a large number of slender bacilli. The diseased lung tissue, from the surface, is red, mottled with minute grayish dots; this mottling is faint in some regions, in others the dots seem to coalesce into grayish patches. The cut surface is grayish red. When compressed, whitish, semi-solid plugs are forced out of the air tubes. In some places these are replaced by a milky, flaky fluid. They consist of leucocytes and epithelium with very few bacteria. No polar-stained bacteria observed. The bronchial and tracheal glands very large, tough, pale pink on section. The trachea and bronchi coated with bright red foam. In the ends of the latter some lung worms.

Pericarditis probably an extension of the pleuritis. Both sides of heart and large vessels contain white thrombi.

A roll culture in gelatine from lung tissue developed a few fungi only.* A rabbit inoculated with lung tissue died in four days. The subcutis of the inoculated thigh much thickened with infiltrated cells (suppuration); over the abdomen also thickened and blood-stained. The cæcum studded with hemorrhagic points and covered with a gelatinous exudate, which is also found on liver. A cover-glass touched to this exudate contains immense numbers of polar-stained bacteria; very few in blood and spleen. *Agar* cultures from these, however, develop in moderate number colonies of swine plague bacteria.

From bits of spleen pulp of the pig an *agar* culture, a gelatine roll culture and a liquid culture were made. The *agar* and the liquid culture contained the motile hog cholera bacilli; the latter also spore-bearing butyric bacilli. The roll contained but two colonies. Of two mice inoculated from the liquid culture one died on the following day; the other in five days, with enlarged spleen, containing hog cholera bacilli in considerable numbers, which were also obtained pure in an *agar* culture. This mouse had its liver and kidneys thoroughly infested with coccidia.

At the same time a pig from another herd near Baltimore was examined. The owner had purchased ten young pigs in May. They began to cough and gradually emaciate about one month ago; since then five had died. One of the survivors, emaciated, very weak, with arched back, "tucked-up" abdomen, and dull, sunken eyes, was killed for examination.

The spleen was not enlarged. The lymphatics in general were enlarged, pale, and firm. Lungs normal, with exception of two or three collapsed areas from one-half to three-fourths of an inch across. Liver and kidneys normal. Catarrhal condition of stomach. In the jejunum a number of ulcers, to two of which *echinorhynchi* are attached. These worms are very likely the cause of the ulcers. In the cæcum and upper colon, especially on and around the valve, were about twenty ulcers, one-half inch across. The slough fell out of most of them while the specimens were being carried from Baltimore to Washington. The ulcers deprived of the slough are nearly circular; the base formed by the muscular wall; the sides vertical, as if the mucosa had been punched out, the border being slightly thickened. The slough itself was yellowish, crumbling. A rabbit inoculated with some of it stirred in sterile water dies in twenty-four hours with slight peritonitis, internal organs generally congested and containing numerous oval swine plague bacteria. A liquid culture from the heart contained only swine plague bacteria, while a gelatine tube culture from the spleen failed to develop.

From the spleen two tubes of nutrient liquid contain a motile bacillus not distinguishable from hog cholera bacilli. A gelatine roll culture contains about six colonies of the same organism.

To test the pathogenic power of this bacillus two mice were inoculated from the liquid culture. One died on the following day, with numerous hog cholera bacilli in spleen and liver. Premature death, due to extensive degeneration of these two organs, which was caused by *coccidia*. The second mouse died on the seventh day, with enlarged spleen and extensive coagulation necrosis in liver. Both organs contain numerous hog cholera bacilli. An *agar* culture from the spleen confirmed the microscopic diagnosis.

We have thus four cases in which both hog cholera and swine plague bacteria are present according to the unequivocal results of bacteriological examination. The same was observed in the outbreak of swine plague which occurred in the beginning of 1887, and

* This swine-plague germ did not, as a rule, grow in gelatine at the ordinary temperature of the room.

which was published in the report of the Department of Agriculture for the same year. In that outbreak the earlier cases examined revealed only swine plague bacteria. Later on both hog cholera and swine plague germs were encountered in the same animal in a certain number of cases. Finally the swine plague died out towards spring and only the hog cholera remained, causing even at that time some very acute cases. The swine plague was the original disease, the hog cholera being grafted upon it when the swine plague pigs from a neighboring farm were placed in pens infected with hog cholera at the station. Even as early as September, 1886, some investigations in Illinois brought out the then remarkable and puzzling fact of two disease germs found in the same animal at the same time.

Before describing the outbreak caused by the pig brought from Baltimore to the Experimental Station, it will be necessary to briefly indicate the condition of things at the latter in order to explain some of the occurrences which followed.

In the beginning of the present year a series of experiments were planned to vaccinate pigs with sterilized cultures of hog cholera bacilli. Experiments of this character are reported as having been begun in the Annual Report of the Bureau of Animal Industry for the year 1886, p. 50. These were not successful on pigs at that time, and it was thought best to inject the sterilized culture liquid in large quantities directly into the peritoneal cavity. Without going into detail, suffice it to say that about twelve pigs were vaccinated in this way, three receiving 800 cubic centimeters in doses of 100 cubic centimeters at intervals of about one week, three 600 cubic centimeters, three 400 cubic centimeters, and three 200 cubic centimeters.

The experiment, including all inoculations, lasted from February 15 to the beginning of April. Owing to some accident or error in the sterilization of the culture liquid this sterilization was not completed in some of the liquid used, although a number of precautions had been taken to insure absolute sterility, which need not be recounted here. One of the animals died of acute hog cholera on the day following one of the inoculations. Its mate died within fourteen days after the same inoculation of hog cholera. Another died within twenty-four hours after one of the injections because of some injury to the intestines during the injection. As these pigs were distributed in groups of three in different pens, it was thought that the accident of using incompletely sterilized cultures was limited to one pen, but subsequent events showed this supposition to be untrue.

The remaining pigs, ten in number, were carefully watched for nearly two months (until May 25), and then brought together into one pen to await a favorable opportunity for exposure to hog cholera. There were in this lot Nos. 482, 483, 484, 490, 491, 493, and Nos. 8, 9, 11, and 12. There were also added Nos. 5, 6, 13, and 15, as control animals. Of these animals, No. 482 died June 13, very much emaciated and with extensive ulceration in the large intestine. No. 493 died July 5, of peritonitis, indirectly due to extensive ulceration of the large intestine. The animal had shown previous to its death no indications of illness. No. 484 died July 15, also of hog cholera. The lesions of this case will serve as an illustration of the others.

Spleen not enlarged. Considerable recent adhesions among coils of large intestine. The mucosa of large intestine contains ulcers as large as silver dollars, with a blackish, irregularly gnawed floor. They only involve the mucosa. About the middle of colon a tumor is situated in the muscular coat of the intestinal wall as large as a

horse chestnut. The contents are whitish, of a putty-like consistency. Attached to the spleen by means of tough, fibrous tissue, evidently part of the omentum, is a cylindrical encysted mass of the same consistency, 3 to 4 inches long and one-half inch wide. These masses represent without doubt the place where the incompletely sterilized culture liquid was deposited by the needle.

In the thorax the ventral lobes of both lungs are enlarged, airless, of a pale reddish, translucent, gelatinous aspect. The bronchi of these lobes are filled with a glairy muco-pus and contain some lung worms. Two rabbits inoculated from an emulsion of lung tissue both died of hog cholera on the eighth and ninth day.

No. 482, found dead September 16, had several old ulcers in the large intestine. The lungs were extensively adherent to the chest wall by old fibrous bands, and in part airless and of a pale red color.

When the Baltimore pig was brought to the station there was what may be considered chronic hog cholera, but no evidence of swine plague as shown by the inoculation of lung tissue from No. 484 into rabbits some time ago, and also the autopsies of the pigs which had died meanwhile. The ulcers were probably directly due to the intra-abdominal injection of the culture liquid supposed to be sterile, and death was brought on chiefly through peritonitis as the result of the ulceration. If the disease, so chronic in character as to elude detection and to last from three to six months, was still capable of infecting other animals it did not do so, as not only four of the vaccinated pigs but also the four control animals were still alive and apparently well.

Soon after the arrival of the sick Baltimore pig it was penned with these survivors, and fresh pigs were put in the infected pen as the inmates died. Thereupon pigs died quite rapidly, with lesions indicating the presence of swine plague and a decided renewal of hog cholera of a virulent type. Vaccinated pigs died very soon after in quick succession, some with marked swine plague lesions. A perusal of the autopsy notes given below will show that they all suffered from old ulceration, except No. 12, which died from injuries received It also appears from the lesions that some of the pigs were very likely infected a second time. As the state of things was very complicated nothing positive can be said as to this point. The notes are simply given to aid in elucidating the subject of swine plague. As to two of the control animals which also died (Nos. 13 and 15), it would be very difficult to state from the autopsy notes whether they had been infected from the inoculated animals before September 20 or had contracted the disease from the Baltimore case. Nos. 5 and 6, the other control animals, died of hog cholera contracted evidently after the arrival of the Baltimore pigs, as the notes will show.

The introduction of the Baltimore pig was followed September 31, eleven days later, by the death of four pigs, Nos. 5, 8, 9, and 11.

September 31.—No. 5, control animal,* found dead this morning. Skin of ventral surface of body reddened; spleen enormously enlarged and congested. Hemorrhagic foci in lungs, but no hepatization. Large intestine deeply reddened and slightly ulcerated. Numerous hog cholera bacilli in spleen.

Pig No. 8, vaccinated animal, found dead this morning. Skin and spleen normal. Inguinal glands enlarged, œdematous, reddened. Liver cirrhosed. Kidneys with medulla congested. Stomach empty, mucosa bile-stained. In ileum several ulcers near valve. Mucosa of cæcum and upper third of colon almost entirely ulcerated; farther down ulcers isolated one-quarter to 1 inch across. Rectum intact. Lungs about twice the usual size when collapsed; over both a pleuritic deposit appearing, either as a mesh-work or as minute dots, which give the pleura a roughened aspect, or as a continuous membrane, according to the quantity of exudate. Slight agglu-

* These terms refer to the vaccination experiment.

tination of lobes to chest walls and to one another. In each pleural sac about a teaspoonful of loose, soft exudate.

The parenchyma of the hepatized regions is in general red, granular on section, with much reddish serum flowing from the cut surface, but the ventral and cephalic lobes are in more advanced stages, some parts being grayish red on section, others containing small foci of a peculiar pale, grayish-yellow color, with outline sharp and sinuous. These are, no doubt, necrotic masses, or sequestra. They are found in the cephalic lobe of the right lung. The same lobe of the left side is in a state of advanced broncho-pneumonia, the smaller air-tubes being filled with a glairy muco-pus. The right principal lobe contains also centers of beginning necrosis. In the bronchial and tracheal glands, which are much enlarged, the cut surface shows grayish scalloped lines in a deeply congested ground. Trachea contains reddish foam. The bronchi contain cylindrical clots of dark and pale color imbedded in mucus; in the smaller bronchi a frothy, thin, red liquid. The immediate cause of death, pulmonary hemorrhage.

Cover-glass preparations from lung tissue show large numbers of polar-stained swine plague bacteria. A rabbit inoculated therefrom died in eight days. The subcutis on the inoculated thigh and contiguous abdominal wall was thickened, pasty, and skirting this a blood-stained, gelatinous exudate. Peritonitis shown by the extensive ecchymosis of the cæcum and a grayish, gelatinous exudate covering spleen, liver, and a small portion of the intestine with a layer of variable thickness. This exudate is made up in part of pus corpuscles and great numbers of polar-stained bacteria. These are also abundant in the subcutaneous infiltrate, but rare in heart's blood. An *agar* culture from the peritoneal exudate contained on the following day a very thin, veil-like growth of swine plague bacteria.

In the barely enlarged spleen of the pig hog cholera bacilli can be detected on cover-glass preparations. A roll culture and an *agar* culture contain the same bacilli only.

Pig No. 9, eight months old, vaccinated animal. Before this animal was placed in the infected pen it was fed portions of the spleen and large intestine of one of the Baltimore cases on September 20.

Skin normal; spleen barely enlarged. Cirrhosis of liver advanced. Kidneys with medullary portion deeply reddened. Lymphatics of meso-colon and near kidneys enlarged and congested. Stomach contains only a small quantity of bile-stained liquid. Duodenum extensively pigmented. Mucosa of cæcum and upper colon almost entirely destroyed, blackish. Below the middle of the colon the ulcers are isolated. The walls thickened and serosa inflamed where ulcers occur.

Lungs diseased; considerable serum in the right pleural sac. The whole of the right lung and the cephalic half of the left hepatized and covered with a pleuritic exudate similar to that in the preceding case. The principal lobe of the right lung is in a state of red hepatization, while the ventral lobe is farther advanced and contains the necrotic foci described under No. 8. The cephalic, ventral, and a portion of the principal lobe of the left lung in the same condition as the corresponding lobes of right side. Bronchial glands enlarged, with reddened cortex. Bronchi filled each with a dark, cylindrical clot. From the red hepatized regions cover-glass preparations show polar-stained bacteria in groups. The polar stain could only be made out clearly when the germs were magnified 1,000 diameters. Roll cultures from the lung tissue were useless, owing to the large number of liquefying germs present. A rabbit inoculated by injecting ¼ cubic centimeter of sterile water in which a bit of lung tissue had been torn up died in three days with a pasty infiltration of the subcutis of thigh and abdomen, slightly blood-stained; in one groin the subcutis very emphysematous. Liver and kidneys congested; spleen scarcely enlarged. Peritoneum of cæcum roughened; extravasations in meso-rectum. Immense numbers of polar-stained bacteria in subcutis as well as on inflamed peritoneum. Very few in spleen and blood. Two *agar* tubes from blood and spleen contained an abundant growth of the same germs next day. A gelatine roll culture from the blood remained sterile. (This germ rarely grew in gelatine at ordinary laboratory temperature.)

From the pig's spleen an *agar* culture contained only hog cholera bacilli. In a roll culture from a bit of spleen tissue about 200 colonies of the same germ and one producing liquefaction.

Pig No. 11, vaccinated, about eight months old; found dead this morning. Skin normal; spleen not enlarged. Lymphatics of large intestine (meso-colon) enlarged and deeply reddened; glands in other regions of the body enlarged, pale. Liver cirrhosed. Kidneys not changed. Stomach empty; mucosa bile-stained, along fundus highly congested. Large patches of superficial ulceration in lower jejunum and ileum. In cæcum and upper colon the mucosa is almost completely destroyed, as if charcoal dust had been rubbed into it. Walls much thickened. Very cu-

riously a large diverticulum near the valve, forming a pouch, has its mucosa intact. Ulceration gradually disappears near rectum.

The lungs are also implicated, but there is no pleuritis. In all lobes are masses of hepatized tissue varying in size, the largest probably 1½ inches in diameter. The hepatization is chiefly of the grayish variety, the tissue being very hard to the touch. Some of these masses contain necrotic foci. The cephalic lobes are replaced by masses of collapsed tissue interspersed with emphysematous tissue. Bronchial glands very large, pale whitish on section. In each bronchus a thin, cylindrical, dark clot imbedded in much glairy mucus. Lung worms in the blind end of both. Cover-glass preparations stained in gentian violet show leucocytes chiefly, with many polar-stained cocci located around the nuclei and very likely imbedded in the cell protoplasm.

A rabbit inoculated from this lung tissue, very sick thirteen days later, was chloroformed. The place of inoculation is occupied by an abscess situated on thigh and abdomen, and firmly attached fascia. No peritonitis. Spleen very large, of a granular appearance, the size due not to engorgement but cell increase. The larger cells have their protoplasm filled with deeply stained granules. A few hog cholera bacilli can be seen. In the liver a few acini have undergone coagulation necrosis. Cultures in *agar* from the abscess and spleen contain only hog cholera bacilli. It is very probable that the swine plague bacteria were destroyed in the organism of the rabbit as indicated by the large abscess and the condition of the spleen.

No. 15, control animal, died October 4. Spleen very large and gorged with blood. The various lymphatic glands of abdomen, excepting those of mesentery, hemorrhagic throughout. Liver and kidneys not affected. Stomach filled with food. In the lowest 8 feet of ileum are a large number of ulcers varying from the size of a pin's head to one-half inch across. The smallest ones are simply superficial sloughs. As they grow larger they become more and more excavated with thickened, puckered periphery. There are also four or five large ulcers of the same appearance encircling the tube transversely. They are all stained deep yellow. The serosa beneath these opaque. The mucosa of the cæcum and about 6 inches of the colon is converted into a tough, partly yellowish, partly blackish necrotic mass, closely adherent to the muscular coat. Wall in general much thickened. Lower down in the colon there are about six oval ulcers three-quarters inch across, with center black, periphery yellowish (resembling buttons), the whole slightly elevated. The neoplastic growth beneath the superficial slough whitish, tough, extending into muscular coat. Farther down a similar ulcer 2 inches across.

Lungs adherent to costal pleura by their anterior portion and to pericardium. The left ventral and a portion of cephalic lobe solid. Tissue grayish-red on section. A slight pressure forces from the air-tubes a thick milky fluid. The principal lobe much congested and œdematous. Of the right lung the ventral is solid and like the corresponding left lobe, excepting that the contents of the air-tubes is consistent, like putty, and can be squeezed out in the form of cylindrical plugs. A portion of the azygos lobe also hepatized. The curdy plugs made up almost entirely of agglutinated pus corpuscles. The thoracic lymphatics with hemorrhagic cortex. Right heart contains dark, semi-coagulated blood, no white thrombi.

This case did not present what might be considered swine plague lesions, judging from the foregoing cases and from previous experience. The lung tissue rubbed on covers contained very few bacteria of any kind. A roll culture on the fifth day contained many colonies of hog cholera bacteria. A rabbit inoculated from lung tissue died in twelve days with very large spleen, coagulation necrosis in liver, and hemorrhagic duodenum. Only hog cholera bacteria obtained from its organs. From the spleen of the same pig a liquid and an *agar* culture contained only hog cholera bacilli.

It is of course impossible to say whether the lung lesions were due to the swine plague germ or not. Certain it is that these organisms die out quite rapidly in lesions as they advance in age, and may thus escape detection. In this case death was due primarily to hog cholera, as the hemorrhagic condition of the lymphatics and the culture indicate.

October 8, No. 6, control animal, found dead this morning. Spleen enormously enlarged. Lungs contain numerous hemorrhagic foci. A small region of one anterior lobe collapsed. No hepatization. From 15 to 20 ulcers in large intestine. Two cultures from spleen remained sterile.

Nos. 13, 16, and 17 are interesting cases, in that they all presented the lesions of both hog cholera and swine plague in an aggravated form. Nos. 16 and 17 were previously fed with the spleen and large intestine of the Baltimore pig (No. 19) before they were placed in the infected pen September 24. No. 17 was found dead October 9; Nos. 13 and 16, October 11.

No. 13, control animal. Skin over pubic region, along median line of abdomen,

inside of limbs, and on throat considerably reddened. Superficial inguinal glands hemorrhagic. Spleen slightly enlarged, dark. Abdominal cavity contained about a pint of fluid, dark-colored fecal matter which had escaped from a perforation in walls of colon. Extensive pale-yellowish exudation matting the various organs together. Cæcum and colon extensively ulcerated. Lungs diseased. Exudative pleuritis gluing lungs to chest wall. Left lung entirely hepatized with exception of a small region near caudal border. Principal lobe in stage of red hepatization. Ventral lobe in general red on section, with numerous small wavy lines and circles or ovals of a grayish color, representing perhaps cell infiltrations about air-tubes. The latter plugged with caseous masses. On this lobe the pleuritic exudate was from one-sixteenth to one-eighth inch thick. Of the right lung the whole ventral lobe was solid, red, mottled faintly with gray; cut surface smooth. Portion of the cephalic lobe in the same condition. Azygos lobe normal. Bronchial glands enlarged, pale pink on section.

In the red hepatized lung tissue and pleuritic exudate a large number of swine plague bacteria could be detected. A rabbit inoculated with lung tissue died in six days with extensive subcutaneous infiltration on thigh and abdomen, spongy, blood-stained. Spleen somewhat enlarged; liver with slight coagulation necrosis. Although we have here the indications of the presence of both germs, only swine plague bacteria were found in an *agar* culture from the spleen.

No. 16, fresh animal. Skin normal; spleen very large, gorged with blood. Liver normal; both kidneys have the medullary portion almost completely absorbed. Ureters distended to a diameter of one-third to one-half inch. Catarrh of bladder. A few stringy deposits on coils of intestine. Lymphatics of large intestine enlarged, indurated, pale. Stomach normal. In lower ileum one large ulcer 2 inches long and several small ones. Large intestine ulcerated. In cæcum the valve is covered with a thin, brick-red slough. Near blind end two button-shaped, flat ulcers, one-half inch across and a large number of very small ones. In the upper half of colon a few ulcers of similar character.

Feeble adhesion of both lungs to chest wall, barely collapsed. All but the azygos lobe and a narrow dorsal strip of lung tissue in each lung hepatized. A membranous exudate covers the diseased portion, thicker ventrally—easily peeled off. In the right lung the hepatization is dark red, granular. The region of the ventral lobe (middle region) shows dorsally necrotic foci (*i. e.*, lobules, or portions of them, of a homogeneous, pale grayish-yellow appearance, very minutely honey-combed, cutting like cheese, and sharply outlined from the surrounding tissue). The ventral lobe itself below these foci has the air-tubes of all sizes filled with caseous cylindrical plugs. The necrotic centers are numerous in the cephalic lobe. The left lung is in substantially the same condition. Bronchial glands enlarged, tough, pale red. White thrombi in all vessels leading to or from heart.

In cover-glass preparations from the recently hepatized lung tissue a considerable number of polar-stained bacteria can be seen. A rabbit inoculated from it died in five days, with extensive pasty infiltration of the subcutis; hemorrhagic points on cæcum; spleen moderately enlarged. An *agar* culture from the spleen contains an abundant growth of swine plague bacteria. Through some oversight the results of cultivations from the spleen of this pig were not noted down.

No. 17, fresh animal. Spleen very large and dark, friable, about 14 inches long, 2½ wide. Superficial inguinals enlarged, with minute petecchiæ on section, and small areas and lines of a pale grayish, waxy cast. Complete loss of medullary substance of both kidneys, due to the formation of cysts varying in diameter from one-half to 1 inch. In left kidney about one-half of cortex also gone; four or five papillæ still show on the median section. In the right kidney only one small cyst in cortex. Liver dark, tough to the touch; lobules on ventral surface slightly projecting. On section the center of acini brownish red, the periphery pale. When scraped the parenchyma comes away as a pultaceous mass, leaving a tough honey-combed frame-work (cirrhotic).

Digestive tract: Mucosa of fundus of stomach wine red; at periphery of œsophageal expansion a blackish patch, three-fourths of an inch across, slightly depressed and covered with islands of yellowish slough. In the cardiac region are numerous erosions from one-sixteenth to one-fourth of an inch across; all covered with a soft, whitish deposit. The mucosa of duodenum has its minute vessels injected and about one small ulcer to a square inch, superficial, with slough stained deep yellow. For 2 feet from the valve the mucosa of ileum contains ulcers varying in size, a few very large, with puckered margin. The cæcum, filled with brownish, soft excreta, contains about 2 dozen ulcers, flattish, center blackish, periphery yellow. The base of these ulcers consists of a neoplastic, whitish, tough tissue. Throughout the colon are small yellowish ulcers, quite superficial, a few even in the rectum.

Thoracic cavity: Right costal pleura and diaphragm of right side covered by a

layer of soft, shreddy material, thickest on the latter. The entire right lung covered with a similar exudate of variable density. The anterior (cephalic) half of this lung hepatized; the hepatization varying from a dark red to a grayish red. The air-tubes are plugged with translucent and opaque whitish plugs. At the caudal tip of the principal lobe a group of lobules, solid, grayish, undergoing caseation. The bronchioles are plugged with white curdy masses, and contain remnants of lung worms. Only one-half of the two anterior (ventral and cephalic) lobes of left lung solid. The remainder of lung œdematous. The azygos lobe completely hepatized, the cut surface of a glistening brownish red, with curdy plugs extruded from the bronchioles on pressure. They are made up chiefly of leucocytes (pus cells). Trachea and bronchi contain a large amount of a viscid, jelly-like material.

Bacteriological examination of the pleuritic exudate revealed among leucocytes a large number of very minute cocci; in some a polar stain is visible. In a few leucocytes the nucleus was situated near one side, and between its two branches the cell protoplasm contained from fifteen to twenty bacteria. A gelatine tube culture made directly from the pleuritic exudate failed to develop. A liquid culture from the same source contained chiefly swine plague bacteria and a few motile hog cholera bacilli. An *agar* culture was covered on the following day with a very delicate growth containing only swine plague bacteria so far as it could be examined. After four days, however, a denser growth invaded the *agar* surface from below, made up of hog cholera bacilli. The lung tissue showed the same organisms in large numbers.

From the spleen only hog cholera bacilli were obtained in a liquid, an *agar* culture, and a gelatine roll culture in which about two hundred colonies appeared.

The following notes refer to fresh pigs (excepting No. 12), which were either simply placed in the infected pen or previously fed with viscera of dead swine. They indicate the decline of the swine plague (lung disease) and a still considerable virulence of the hog cholera.

October 3.—No. 12, vaccinated animal, found dead this morning. Pleural and abdominal cavity contain considerable blood-stained serum. Blood extravasation in muscular tissue of abdomen along median line. Cæcum and upper colon filled with small pebbles. Death from injury. A culture from spleen remains sterile.

October 8.—Nos. 39 and 40, fed with viscera of hog cholera cases October 1, dead this morning. In No. 39 the mucosa of ileum and large intestine was necrosed superficially in the form of a thin layer. Lungs, with exception of a small patch of collapse on left ventral lobe one-half inch square, normal. Spleen contains hog cholera bacilli. In No. 40 the lesions were the same. The lungs were normal but contained lung worms.

October 10.—Nos. 1 and 2, fed with viscera of dead pigs September 31, found dead this moring. In both there was extensive necrosis in ileum and large intestine, while the lungs were normal. Cultures from the spleen of No. 2 contain only hog cholera bacilli.

Nos. 41 and 42 fed together with Nos. 39 and 40, with hog cholera viscera, October 1; both dead this morning. In both the mucosa of ileum and large intestine was necrosed; the lungs were entirely normal. Cultures from the spleens of both on *agar* contained only hog cholera bacilli.

October 15.—No. 467, exposed since September 20, found dead this morning. *Post-mortem* changes begun. Thorax and abdomen contain a considerable quantity of bluish-red serum of an offensive odor. Spleen enlarged, congested. Lymphatics of groin hemorrhagic. No ulcers in large intestine, but mucosa highly inflamed. Lungs contain a few hemorrhagic points, otherwise entirely normal.

October 18.—No. 71, exposed October 8, dead this morning. Lungs normal. The lesions are confined to digestive tract. Slight diphtheritic deposit on mucosa of lower ileum. In cæcum and colon, the deep wine-red mucosa is studded with a large number of small ulcers. Culture on *agar* from spleen contains only hog cholera colonies.

October 19.—No. 73, exposed October 8, dead this morning. Spleen enlarged and lymphatics generally hemorrhagic. Lungs contain numerous hemorrhagic centers from one to four lines across. In each ventral lobe a small region collapsed; no hepatization. Kidneys contain hemorrhagic points. Extensive ulceration of cæcum and colon. Culture from spleen contains hog cholera bacilli.

October 21.—No. 74, fed with viscera from diseased pigs October 13, died this morning. Extensive ulceration in both large and small intestines. Spleen engorged. Lungs normal.

October 22.—No. 72, exposed October 8, dead this morning. In this case we again

meet with lung disease. Lung small. Left lung roughened on the entire surface, condensing in some places into a delicate mesh-work. The lesser half of principal, the whole of ventral, and portion of cephalic lobe airless. In the principal lobe the hepatization varies from a catarrhal plugging of air-tubes and alveoli, near the caudal tip, to a dark-red croupous condition towards the center of the lobe. The right lung is free from pleuritis. On the diaphragmatic surface of principal lobe are from six to seven patches from one-half to 1 square inch in area of a bright red, mottled regularly with grayish-yellow points. On section these hepatized regions are of a grayish pink, mottled with deep red. The air-tubes exude a soapy fluid on compression. The ventral lobe and a portion of the principal lobe in the same condition. Bronchial glands enlarged, firm, slightly reddened. In both bronchi a large number of lung worms, which are very probably the cause of much of the broncho-pneumonia. No inoculations were made from it.

Spleen slightly enlarged, congested. A small quantity of blood-colored serum in the abdominal cavity and some fibrils. Kidneys with numerous hemorrhagic points in medulla. Stomach and duodenum normal; five ascarides lodged in common bile duct. In ileum the walls are triple the normal thickness; the mucosa is converted superficially into a yellow, leather-like, creased surface; when this necrosed mass is forcibly scraped away a deep wine-colored tissue is exposed. In the colon the deeply reddened membrane is studded with about twelve small ulcers to a square inch. In the cæcum the entire membrane is involved down to the muscular coat.

No. 70, exposed since October 8, dies this evening. Lungs normal. Lesions limited to digestive tract and as severe as those of No. 72, just described.

October 23.—No. 68, exposed since October 8, dead this morning. Spleen enlarged. Lungs with petecchiæ on surface; no broncho-pneumonia. Mucosa of large intestine deeply congested and beset with very many small ulcers.

October 24.—No. 75, fed with diseased viscera October 13, and since then exposed in infected pen, dead this morning. Spleen enlarged; large intestine extensively ulcerated. Lungs normal.

October 26.—No. 67, exposed since October 8, dead this morning. Ventral surface of body reddened. Spleen enlarged and dark, friable. Lymphatics in general enlarged, indurated, pale. Mucosa of great curvature of stomach intensely inflamed. About 70 ulcers present, partly hemorrhagic. Small superficial ulcers throughout small intestine, with lemon-yellow slough. The entire large intestine contains them, including rectum, about one-eighth to one-half inch across. Slough of a dirty-yellowish color. Lungs normal.

October 27.—No. 468, pig about one year old, exposed since October 1, found dead this morning without any marked signs of previous illness. Spleen enlarged, with numerous hemorrhagic infarcts. Considerable blood-stained serum in abdominal cavity. Lymphatics generally with cortex or entire substance hemorrhagic. A few hemorrhagic spots in stomach. The serosa highly inflamed; several small ulcers near valve. Mucosa of large intestine dotted with petecchiæ and discolored with diffuse extravasation. Kidney with cortex and medulla pervaded with punctiform hemorrhages. Several ulcers with neoplastic base in cæcum. Right lung lightly glued to chest wall. Considerable hemorrhage in this pleural sac. Over the major portion of the pleura of the right lung, after removal, a closely adherent, thin, opaque, false membrane. The tip of ventral and cephalic lobe collapsed. The pleura of the cephalic (anterior) half of left lung covered by a delicate network of exudate. Collapse as in right lung. In general the various lobes are glued together. The lung tissue itself is pervaded with small hemorrhages, and œdematous. No hepatization. Bronchial glands hemorrhagic. From the spleen several cultures (*agar* and liquid) contain only hog cholera bacilli. These are visible in large numbers on cover-glass preparations of spleen pulp. Gelatine roll cultures show the same organisms.

November 2.—No. 66, exposed since October 18, dead this morning. *Post-mortem.* Decomposition advanced. Peritonitis. Extensive ulceration of lower ileum and large intestine. Ventral lobes of lungs airless. Lung tissue with hemorrhagic points.

November 3.—No. 81, exposed October 22, dead this morning. Large intestine with mucosa highly inflamed and slightly ulcerated. Lungs normal.

November 4.—No. 80, exposed since October 22, dead this morning. Intense congestion of mucosa of large intestine, also numerous ulcers. The mucosa of ileum for 3 feet from valve completely necrosed. Lungs normal.

December 7.—No. 94, exposed since November 28, dead this moning. Ulceration beginning in the large intestine. Lungs with a few hemorrhagic foci; otherwise normal.

December 8.—No. 54, exposed since November 13, dead this morning. Several old ulcers in large intestine. Lungs normal.

In this connection the following case is of great interest, not only in showing the extent to which swine plague may go in the destruction of lung tissue, but also in showing that animals may live for some time with only a small portion of the lung tissue capable of performing its function:

No. 463 had been exposed to hog cholera at the beginning of 1888, but did not take the disease. It was used subsequently for experiments on purgatives, and dosed with calomel several times. October 1 it was placed in the infected hog cholera and swine plague pen. It had been thin and unthrifty for several months previous, and failed to grow in weight. After staying in this pen for more than three months, apparently resisting infection, it suddenly died January 14. The abdominal organs were in general healthy, excepting the liver, which was cirrhosed. When cut a gritty sensation was imparted to the hand. The stomach was also catarrhal. There were no ulcers in the intestinal tract.

The lungs were extensively diseased. All but about one-fourth of the right lung and one-sixth of the left lung solid. These regions were situated on the dorsal aspect of the principal lobe, and were very hyperæmic. The remainder of the lung tissue (with exceptions to be given) is converted into a yellowish-white, homogeneous mass, having the consistency of rubber to the touch, and cutting like moderately hard cheese. Scraping brings away scarcely any of the tissue. The interlobular tissue and small bronchioles show very faintly or are effaced. In several places the hepatized tissue is breaking down into a pasty, grayish mass. In the left principal lobe a sequestrum, nearly 2 inches in diameter, of a putty-like consistency. The right ventral lobe is also well-nigh converted into the same pasty material, and the centre of the azygos lobe is softening.

The various lobes are bound together by tough fibrous tissue. The pleura is everywhere thickened by the formation of bands and patches of fibrous tissue.

In order to test the pathogenic effect of this germ, the following inoculations were made in addition to those upon rabbits already described:

Two fowls which were inoculated into the pectoral with 1 cubic centimeter each of a liquid culture showed no signs of disease. Two pigeons inoculated with $\frac{1}{2}$ cubic centimeter each likewise resisted successfully.

Two mice received about $\frac{1}{10}$ cubic centimeter of a liquid culture under the skin near the root of the tail. One died on the second, the other on the third day after inoculation. In the spleen and heart's blood of both were large numbers of polar-stained swine plague bacteria. In one of them a gelatinous exudate on the pleura consisted of immense numbers of these germs, together with many leucocytes, whose protoplasm was gorged with them. The lungs were in part hepatized. (In both mice the duodenum was greatly distended by masses of tape-worms; in one the liver and kidneys were far advanced in fatty degeneration. These pathological conditions no doubt hastened the fatal result.)

Effect on pigs.—Our past experience with this germ is that it is difficult to predict results of inoculation into pigs unless large quantities are injected. This is particularly true when the germs are obtained from an outbreak of a mild character, as was the case with the one under consideration. The following inoculations without any result confirm this past experience:*

October 8.—From an *agar* culture obtained from a rabbit inoculated with lung tissue (pig No. 9), the condensation water containing an abundant growth of swine plague bacteria was mixed with 10 cubic centimeters of sterile bouillon. A bouillon peptone culture from the same source was added to this, making 20 cubic centimeters in all. One pig (No. 36) was inoculated subcutaneously with 10 cubic centimeters of the culture liquid, one-half into each thigh. No. 37 was inoculated into the right lung through the chest wall, receiving 3 cubic centimeters. No. 38 was inoculated in the same place, 2 cubic centimeters being injected.

No. 36 manifested no ill effects, being watched several months. No. 37 likewise remained well. No. 38 began to decline about a month after the inoculation, and three months after appeared stunted and unthrifty although it ate very well. Owing to its poor condition it was killed January 23. There were no lesions of ab-

*Compare with these similar inoculations made with swine plague germs from a severe Iowa outbreak, p. 193.

dominal or thoracic organs, excepting a few membranous expansions of connective tissue fastening the ventral border of a part of the right lung to the chest wall. Closer examination revealed an old pleuritis, indicated by small shreds of fibrous tissue firmly adherent to the convex surface of the same lung. In the cephalic lobe were two or three small collapsed masses. The lungs were sound with this exception.

SOME GENERAL OBSERVATIONS ON THIS EPIZOOTIC.

As already stated, in the latter part of September three pigs from one herd and one from another in the vicinity of Baltimore, Md., were found to contain the lesions as well as the germs of two infectious diseases. One of these pigs communicated both diseases to pigs at the Experiment Station. The swine plague rose rapidly in severity and then fell equally fast, and almost disappeared within a month after its introduction. The hog cholera, however, continued until the middle of January, 1889, with variable severity. Moreover, not all animals took swine plague, while none of them died of that disease alone. Previous observations have shown that swine plague did not last very long, at least not so long as hog cholera when associated with it. That it may, however, become exceptionally severe is proved by investigations made in Iowa in November, 1888, and reported below.

Before speaking of the characters of the disease as observed in this outbreak, it must be said that it is by no means safe to make deductions as to the lesions caused by one disease germ or another in the same animal when we have a double disease to deal with. Hence the brief statements made must be considered merely as opinions rather than positive statements. The lung disease is especially puzzling, in so far as the lesions in different lungs and in different parts of the same lungs are of such different character. I am of the opinion that swine plague causes a pneumonia essentially catarrhal in character. In this outbreak, however, much of the pneumonia appeared croupous, *i. e.*, red, granular. A certain number of cases died of pulmonary hemorrhages, and I am inclined to think that the hemorrhage and the red hepatization were resultants of hemorrhagic lesions of the lung tissue so common in uncomplicated hog cholera. Usually the dependent lobes appeared to be affected with a chronic broncho-pneumonia, upon which the swine plague was grafted secondarily. It was quite common to find the ventral lobes with the air-tubes filled with yellowish-white consistent plugs, or else creamy in character, while other portions were involved in simple pneumonia without implication of the air-tubes. Knowing, as we do, that broncho-pneumonia is not uncommon both in young pigs free from any infectious disease and in such as die of hog cholera, it is reasonable to suppose that such lungs are especially vulnerable in the presence of swine plague virus.

In a considerable number of cases lobules were found, chiefly in the middle and cephalic third of the lungs, apparently necrosed. On microscopic examination such lobules contained a variety of bacteria, chiefly streptococci, ranged along the periphery of the lobule in large masses or colonies, which were brought out very well by the Gram-Weigert stain. It is probable that the lobule became necrosed because of the plugging of its vessels by thrombi, and that these bacteria invaded it as putrefactive forms. At the same time we must admit that so far as we know the process may be the very opposite.

Frequently the disease process is still more complicated by lesions

due to lung worms. In some lungs the caudal tip of the large principal lobe on both sides was converted into a solid, rather hard, grayish-yellow mass, evidently due to the irritation of lung worms which settle in this locality. It is probable that swine plague may start in such a nidus, although the peculiar hepatization is not originally due to swine plague.

In the cases of swine plague, pleuritis was a common and prominent lesion, directly traceable to the virus. It is not unlikely that pleuritis in old cases of hog cholera is caused now and then by septic organisms entering the serous cavities through the ulcerations in the large intestines.

It is interesting to note, although not belonging to this outbreak, the uniformity with which ulceration of the large intestine accompanied intra-abdominal injection of hog cholera bacilli in the vaccination experiment. The superficial character of most of the ulcerations would lead us to assume that the virus had acted upon the mucous membrane from the surface rather than in the form of emboli from the sub-mucosa, in which case we should expect the ulcers to be deep and rather small in size. But there was no evidence, except in one case (No. 484), of injury to the wall, and we may have to accept the alternative that only two or three animals were inoculated within sufficiently sterilized cultures, and that the remainder took the disease from these by taking the virus in with the food.

The experiment of intra-abdominal injection of sterilized cultures in large quantities has since been repeated without any accident, and will be reported when completed.

INVESTIGATIONS OF SWINE DISEASES IN IOWA.

In determining upon rules and regulations necessary for the suppression and prevention of infectious diseases it is necessary to know their causes and all that pertains to their life history. As long as these are not fully known the rules that are laid down can only be regarded as provisional and subject to change after more thorough investigations. For the same reason the preventive measures applicable to one disease can not be applied to another if there are differences in the microbes that cause the diseases. We have already demonstrated in this and former reports that all infectious swine diseases in our country are not the same. We have separated them into two diseases, hog cholera and swine plague. Although there is much that is alike in both diseases and in the bacteria causing them, the latter are distinguished from one another in a number of ways, the most important of which is a difference in their resistance to destruction and their behavior in the surroundings of the animals, such as soil, water, etc.

One of the problems before us now is to determine the relative distribution of these two diseases in our country. Are there certain regions overrun by one of these diseases and free from the other? What regions are afflicted with both diseases?

It was to aid in solving these questions that advantage was taken of the reported prevalence of swine disease about Mason City, Iowa, in November, 1888. Owing to the very willing assistance of Messrs. L. M. Van Auken, H. I. Smith, and others, of Mason City, in locating for us the places where the disease existed, and in furnishing valuable information concerning the spread of disease in that section of the country, as well as the readiness with which the owners of

diseased swine placed all the means and animals at our disposal, it was possible to examine several animals from three separate farms within two days. Owing to the exigencies of bacteriological work it is necessary to work quickly in order to obtain any results.

Farm A.—The disease appeared about November 1, in a herd of sixty-five shoats, weighing at the time from 80 to 160 pounds each. They were kept in a one-acre lot at the time the disease appeared and fed upon all the new corn they would eat, together with slops from the house. The pigs were all dead at the beginning of December. Of this herd, three pigs were examined on November 13, *i. e.*, in the middle of the outbreak.

November 13.—Pig No. 1, black female shoat, died either yesterday afternoon or last night, during which there had been a heavy frost. Superficial inguinal glands very much enlarged, dark red. On section, mottled with grayish lines and circles, probably due to cell infiltration of the lymph channels. The ventral lobes of both lungs collapsed, flesh red. Broncho-pneumonia in its early stages; no pleuritis. Spleen but moderately enlarged, not congested. In peritoneal cavity, on coils of large intestine, a few stringy, loose deposits of fibrin. Kidneys normal. On the mucosa of the large intestine a very thin membranous deposit not much thicker than heavy paper. It is easily peeled off, showing a deep wine-red surface beneath. The blind end of the cæcum is converted by a transverse partition of inflammatory origin into a closed cavity larger than a hen's egg. The walls of this sac are at least half an inch thick, and the surface of the partition facing the colon is covered by a thick yellowish mass, partly necrotic, partly neoplastic. This may have been the result of ulceration. An *agar* culture of the spleen made with a bit of tissue remained sterile.

A portion of the mucosa of large intestine and of the diseased lung tissue were placed in sterile, plugged test-tubes and kept in the cold.

On December 1, a portion of each was torn up in sterile bouillon and injected hypodermically into two rabbits. The one inoculated from the intestine remained alive and well, but the other died in three days. There was a sanguinolent, cellular thickening of the subcutis of the inoculated thigh and adjacent groin. The thigh muscles under the exudate were of a grayish color and faintly ecchymosed. There was peritonitis indicated by ecchymosis of the serous surface of cæcum and a membranous exudate on spleen and liver. The dorsal wall of the peritoneal cavity and the serosa of rectum were also involved. Liver, spleen, and kidneys much congested. On section the medullary portion of kidneys wells up slightly above the cortical portion. In left lung 5 to 6 foci of dark red hepatization. A cover-glass applied to the exudate on spleen shows an immense number of cocci and a small number of leucocytes. In blood and spleen pulp they are rare. An *agar* culture from the latter and a bouillon culture of the former are both pure cultures of what seems to be the swine plague germ.

About one month later (January 3) a fresh rabbit was inoculated from an *agar* culture meanwhile renewed several times. A little of the growth was diluted in sterile beef infusion and $\frac{1}{4}$ cubic centimeter injected subcutaneously. The rabbit died on the fourth day, with extensive lesions of the subcutis of abdomen and thigh, partly yellowish, pasty suppuration, partly ecchymotic. The peritoneal cavity was affected in the same way, the lesions being exudative, partly hemorrhagic. The same organisms injected were found in the exudate and internal organs on cover-glass preparations and by cultivation.

Pig. No. 2, small red male. Hair almost entirely shed; very much emaciated; died yesterday. Lymphatic glands of inguinal region enlarged, pale red. Changes similar to those in No. 1, but much less marked. Lungs normal, excepting the very tip of one lobe. Spleen moderately enlarged but considerably congested. Kidneys normal. On opening abdomen, the ulceration of the large intestine was manifest from the serous surface of the coils, between which in the meso-colon there was a gelatinous exudate; the meso-colic glands as large as small beans. The cæcum was glued fast to the adjacent kidney and a clot as large as a marble adherent to the former in another place. When opened, four deep ulcers were found in the cæcum. When the superficial slough was scraped away the tissue beneath was found infiltrated with blood. The mucosa of entire colon was beset with superficial sloughs, chiefly on the ridges, and small round ulcers more sparingly disseminated.

Portions of the diseased mucosa were cut out and preserved in the cold in sterile, plugged test tubes. November 20, a rabbit was inoculated by placing a portion of an

ulcer under the skin of the thigh. This rabbit lived until December 7, seventeen days after inoculation. Over the pubis a tumor as large as a hen's egg, which seems to consist of the thigh muscles greatly enlarged by abscesses between the bundles of fibers; contents of abscesses cheesy. Over the abdomen thickening of subcutis, with sero-gelatinous exudate on periphery of thickened area. On epicardium a gelatinous deposit, and in heart muscle about six whitish, homogeneous masses from one-eighth to one-quarter inch in diameter. Spleen slightly enlarged, dark. No bacteria to be seen in spleen pulp, but the large pale cells have their protoplasm filled with deeply stained (methylene blue) points. In the belief that the local effect of the inoculation was the cause of death, as the rabbit had lived so long, only two tubes of *agar* were inoculated with bits of the enlarged thigh muscle. These remained sterile.

On December 1 another ulcer was inoculated by tearing it up in sterile water and injecting ½ cubic centimeter of the suspension of ulcerated tissue. This had been kept in the refrigerator or the outside air since it was collected. It was, however, considerably decomposed. The rabbit died December 11. There was in this case also extensive pasty thickening of the subcutis over the thigh and abdomen about one-quarter inch thick. No peritonitis. Spleen enlarged, dark, softened. Lungs pale; blood dark, coagulated very imperfectly. In the cæcum for about 3 inches from the blind end are about eight ulcers. The surface of the ulcers is hemorrhagic, the base made up of thickened pale-red tissue. The genesis of these ulcers was explained in subsequent cases as a caseous (suppurative) condition of the follicles in the walls of the intestine, which broke through the membrane and caused hemorrhage on the mucous surface. They may have been due to emboli from the inflamed subcutis, which was very likely the cause of the abscesses in the heart muscle of the preceding case.

Cover-glass preparations from the spleen, liver, blood, and subcutaneous infiltrations revealed no bacteria, but a considerable number of leucocytes with elongated or divided nucleus, in the protoplasm of which were numerous punctiform bodies deeply stained (methylene blue). *Agar* tubes were inoculated from liver, spleen, and blood. All but one remained sterile. This contained a motile bacillus very much like the hog cholera germ, but it grew more vigorously on *agar* and liquefied gelatine, besides having no effect on mice and rabbits. The swine plague germ was therefore not obtained in cultures from these rabbits.

At the same time (November 3) a shoat (No. 3) was killed for examination which was reported to have been sick for some time. On the back of the neck there was an area 3 to 4 inches in diameter, from which the skin had sloughed away, and in which the muscular tissue was exposed to view. This may have accounted, perhaps, for the illness, since nothing abnormal was found in the animal excepting collapse of the left ventral lobe of the lungs in which broncho-pneumonia was not yet apparent. The intestines were normal.

Farm B.—The disease had appeared about the middle of October in a herd of 63 shoats and 12 old hogs. By the end of the year 53 shoats and 5 old hogs were dead, and the disease practically extinct. When the disease broke out the shoats occupied a 40-acre corn field, and were also fed with skimmed milk and slops from the house. The old hogs were penned, receiving all the corn they could eat. The examination included the following cases:

November 14, No. 4, small pig, probably died yesterday noon. Temperature of the air below freezing. Emaciated. The disease seems limited to the lungs and digestive tract. The former have the ventral lobes airless, of a red flesh color. In the other lobes are a number of scattered foci of collapse and beginning pneumonia. The large intestines are extensively ulcerated, there being at least 3 ulcers to 1 square inch of mucosa. In some places the necrosis is in the form of bands parallel to the ridges or folds of the membrane. The lowest foot of the mucosa in the ileum is completely converted into a slough.

From the spleen, which is small and pale, two bits were placed in *agar* tubes, though no bacteria were seen on one cover-glass of spleen pulp. One tube remained permanently free from growth; the other developed a dense whitish, glistening growth, extending upward from the spleen tissue on the surface of the *agar*. In bouillon peptone it grew slightly more turbid than the hog cholera germ, but had the same form and was motile. On gelatine it grew without producing liquefaction. From the liquid culture two mice and a rabbit were inoculated November 28. One of the mice was found dead on the fifth day. In each lung dark red foci of hepatization. Intestines in part blackish, also stomach near pylorus, evidently due to tarry contents, which may have been due to hemorrhage, although it was

impossible to decide this point, owing to the small size of the animal. In the small spleen a few bacteria were seen, but no cultures were made therefrom in the expectation of getting better results from the other mouse and the rabbit. But both of these remained well, so no importance was attached to it. The mouse killed with chloroform one month after inoculation showed no lesions of any kind.

On December 1, two mice and a rabbit were inoculated from an ulcer of the same pig kept in a sterile test tube in the refrigerator. None of these animals showed signs of illness thereafter.

No. 5, a small pig, said to have died forty-eight hours ago. On examination no lesions were found in lungs or intestines. Two tubes of *agar* into which bits of the small, pale spleen were put remained sterile.

No. 6, of the same size as the two preceding, said to have died about forty-eight hours ago. The ulceration in the large intestines was as extensive as in No. 4. Of the lungs one ventral lobe was hepatized. From the spleen, which was considerably enlarged and congested but rather firm, two *agar* cultures were made. These remained sterile, although cover-glass preparations had shown the presence of streptococci. Six days later a rabbit inoculated from an ulcer, meanwhile kept in the cold, remained well.

The results of inoculations and cultures from these three cases were thus entirely negative.

Farm C.—The disease appeared about November 1 in a herd of 14 shoats and 2 old hogs. The shoats, weighing from 125 to 175 pounds each, were all dead before November 20. They had been kept in pens with a small yard to run in, and were being fed on all the new corn and water they could consume, together with skimmed milk and slops from the house. From this herd the following animals were examined:

November 14, No. 7, black shoat, weighing about 125 pounds, just dead, the viscera still quite warm. The animal is in very good condition, although the owner claimed that it had lost at least 50 pounds during its illness. The lungs are perfect excepting the tip of one ventral lobe, where a portion as large as a small marble is solid. Superficial inguinal glands very large and with cortex hemorrhagic. Glands of lesser omentum in the same condition. The lower coils of the ileum show under the serosa punctiform extravasations; the walls are thickened and the mucosa itself is concealed by patches of soft yellowish-white exudate about one-tenth inch thick. It is easily peeled off and exposes a deeply reddened membrane. The large intestine, beginning with cæcum, is extensively ulcerated, the ulcers being in general shallow and extended. From the spleen, which was very large and gorged with blood, two bits of tissue were placed in *agar* tubes. These remained sterile. No bacteria could be detected in spleen tissue with the microscope.

From one of the ulcers a rabbit was inoculated November 20 by placing a small bit of the ulcerated tissue under the skin and drawing the incision together with a single stitch. The animal died in six days. The subcutis of the inoculated thigh was considerably infiltrated, on the abdomen only slightly so. On the opposite thigh near the pubis a small patch of hemorrhagic points on the muscular tissue. No peritonitis. Spleen congested, but barely augmented in size. In spleen and blood no bacteria could be detected; the leucocytes there contained the stained particles, as before described. Two *agar* and two bouillon peptone tubes were inoculated from the blood and spleen pulp. All four tubes remained sterile.

No. 8, animal about the size of No. 7, died last night. Superficial inguinal glands with cortex reddened, and occasional hemorrhagic points in medulla, which has a decided greenish-yellow tinge.

All but a narrow portion along the dorsal region of each lung solid, twice as large as in the collapsed condition. No pleuritis. The entire hepatized tissue contains whitish, cheesy masses, from 1 to 4 millimeters (one twenty-fifth to four twenty-fifths of an inch) across, which are consistent, so that the whole lung cuts like liver tissue. The masses are so numerous as to leave but little reddened lung tissue between them; odor moderately putrefactive. Liver has a peculiar mahogany color, indicating stasis of the bile in the bile capillaries and ducts. The acini are plainly outlined, bloodless. Spleen exceedingly large, due to engorgement with blood. In the cæcum a large ulcer near the valve, about 1½ inches across, besides six or seven smaller ones one-fourth to one-half inch across, the yellowish slough slightly projecting.

From the lung a rabbit was inoculated November 21. A bit of lung tissue was teased and broken up in sterile bouillon and injected subcutaneously into the thigh. The rabbit was dead on November 24. The injection had caused considerable pasty

thickening of the subcutis on the thigh. The spleen was enlarged and dark colored. Other lesions absent. Cover-glass preparations fail to show bacteria in spleen, liver, and heart's blood. From the spleen and the blood each an *agar* and a bouillon peptone tube were inoculated. The two *agar* and one bouillon tube contained, on the following day, growths which proved to be made up only of swine plague bacteria. The other bouillon tube contained also a short non-motile bacillus.

Another rabbit had been inoculated at the same time by placing a small bit from one of the ulcers of the cæcum under the skin on the inner surface of the thigh. This animal was found dead November 27. There was in this case but slight suppurative infiltration of the subcutis at the point of inoculation and a few petecchiæ on abdominal muscles. Spleen small, dark; liver congested and in an advanced state of fatty degeneration. *Cysticerci* in omentum. In the spleen, liver, and blood an immense number of swine plague bacteria, showing very clearly the polar stain. Cultures in *agar* and in bouillon peptone from the spleen and heart's blood contained on the following day only swine plague bacteria. A tube of gelatine inoculated at the time failed to grow. Swine plague bacteria were thus obtained from both intestine and lungs of No. 8.

No. 9, in size and weight like the two preceding. So sick that it was thought best to kill it. In this animal there was no ulceration of the large intestines, but in the ventral portion of the left lung the broncho-pneumonia, so advanced in No. 8, was already established. The spleen was moderately engorged with blood. Two *agar* cultures from spleen bits remain sterile. From a bit of lung tissue a rabbit was inoculated into the thigh subcutaneously on November 21. It was found dead November 25. The local lesion involves the subcutaneous connective tissue of thigh and abdomen. The muscular tissue underneath is grayish, discolored. The subcutis overlying it is thickened and softened, partly gelatinous, and infiltrated with blood in the groin. The cæcum directly underlying the subcutaneous inflammation of the abdomen is dotted with hemorrhages and about 3 inches of the blind end has its walls very much thickened, softened, the serous aspect discolored with blood extravasations, and the mucosa grayish, softened, the contents of a semi-gelatinous, colorless aspect. Slight exudate on the ventral surface of the liver. The subcutaneous and peritoneal exudates contain an immense number of cocci; in the blood they are few in number. None show any distinct polar stain. *Agar* cultures from the peritoneal exudate and from heart's blood contain, on the following day, a growth of swine plague bacteria only.

No. 10, small shoat, died only a few hours ago. All of left lung but a small strip of dorsal region hepatized. The principal lobe is in a condition of dark red hepatization interspersed with areas of a paler color. Over the ventral lobe, on its lateral aspect, an exudate nearly one-eighth inch thick, lamellar, easily scraped away as a yellowish-white pultaceous mass. The lung tissue beneath it in a state of advanced cellular infiltration (broncho-pneumonia). The ventral lobe of the right lung is likewise involved in broncho-pneumonia. In the cæcum near the valve a slightly depressed, ragged, gnawed ulcer about 1 inch across. The mucosa of the entire valve is also ulcerated. No lesions lower down. From the slightly congested but not enlarged spleen two *agar* cultures were made. These remained sterile.

On November 21 a rabbit was inoculated subcutaneously with one-fourth cubic centimeter of an emulsion of the lung tissue in sterile beef infusion. This rabbit remained alive and apparently well. December 17, nearly a month later, it was killed with chloroform. A large ulcer had formed on abdomen, exposing the thickened subcutis firmly attached to subjacent muscular tissue. No peritonitis. Spleen small and pale, liver dark. Stomach well filled with food. In the walls of the cæcum near the blind end about a dozen whitish patches, the largest about three-sixteenths of an inch across, the smallest barely visible. These patches correspond to soft white masses, probably lymph follicles undergoing suppuration. In the left lung a small area of hepatized tissue. The process in this case had been localized in the subcutis, and the condition in the cæcum may have been due to embolism.

On December 1 a second rabbit was inoculated in the same way from the same material, kept meanwhile in the refrigerator. The result was entirely negative.

The virulence of pure cultures of the swine plague bacteria obtained from pigs Nos. 8 and 9 by inoculation into rabbits was tested about a month later on rabbits by suspending a loop full of the gelatinous growth from the condensation water of *agar* cultures in about 1 cubic centimeter of sterile water, and injecting one-eighth of this amount subcutaneously. Rabbit inoculated from culture from pig No. 8, January 2, dead next morning—in less than twenty hours. Slight infiltration of the subcutis of inoculated thigh with ecchymoses and discoloration of the subjacent muscle. Lymph gland of groin hemorrhagic. In the internal organs no changes, no peritonitis. Spleen dark, slightly enlarged. In spleen and liver an immense number of polar-stained swine plague bacteria.

Rabbit inoculated from culture from pig No. 9, January 8, died within forty-eight hours. The lesion at the place of inoculation somewhat more pronounced and extending to abdomen. In the latter cavity the cæcum and portion of colon densely sprinkled with subserous punctiform extravasations, portions of rectum and duodenum reddened. A grayish viscid exudate between the cæcum and colon, on liver and spleen. The exudate consists chiefly of swine plague bacteria, which are also present in the spleen and blood.

The following table gives the results of cultivation and inoculation experiments:

Date of autopsy.	Swine No.	Spleen cultures on *agar* made within twenty-four hours.	Rabbit inoculated with ulcer.	Rabbit inoculated with lung tissue.
Nov. 13	1	Sterile	December 1, no result	December 1, swine plague.
	2	......do	November 20, no result; December 1, doubtful.	
	3			
Nov. 14	4	Putrefactive germ in one tube.	One rabbit, two mice, no result.	
	5	Sterile		
	6	......do	November 20, no result	
	7	......do	November 20, doubtful	
	8	......do	November 21, swine plague	November 21, swine plague
	9	......do		Do.
	10	......do		November 21, no result. December 1, no result.

From the notes and the tabulated results it will be seen that the disease under examination is not hog cholera. This is abundantly proved by the absence of hog cholera bacilli from the spleen in all cases examined. In true hog cholera these bacilli are rarely missed when bits of spleen tissue are taken for culture, and in many cases a prick of the platinum wire into the spleen is sufficient to produce a copious growth. In the second place, inoculation of rabbits with material from intestinal ulcers is also quite invariably successful in true hog cholera in isolating the bacilli. Lastly, inoculations of rabbits from diseased lung tissue in hog cholera are successful in most cases. We have in the investigation before us therefore not the slightest evidence that hog cholera germs were present in the diseased animals. It might be objected that some of the inoculations were made so long after the material had been collected that the specific germs died meanwhile or were destroyed by the multiplication of putrefactive organisms. But this objection may be answered by the fact that hog cholera bacilli are very hardy, and could not have been destroyed in the time elapsing between *post-mortem* examination and inoculation into animals, which was either seven or sixteen days, as indicated in the table. During this period great care was taken to keep the material in the cold and in a condition favorable to drying (sterile test tubes plugged with cotton wool). Drying fails to destroy hog cholera bacilli, especially when surrounded by or imbedded in other material, within one month at the shortest. When these facts are taken into consideration, the disease can not be pronounced hog cholera, although strikingly resembling it in most of the animals examined. There is but one alternative to be considered. The germ producing the disease in the intestinal tract may not be accessible by the methods which were used, *i. e.*, it may not be capable of infecting rabbits and mice and destroying them. It may be limited to the mucous membrane of the digestive tract so that it can not be obtained in cultures made from internal organs, such as the spleen. This theory seemed at first a probable one when a few of the inoculated

rabbits died with what appeared to be metastatic abscesses in the walls of the cæcum, in one case in the heart muscle, although all the cultures from these animals remained sterile. It seemed reasonable to assume that the microbe in these cases multiplied in the abscesses only. When, however, the same disease in rabbits was caused by inoculating them subcutaneously with the contents of the cæcum of healthy swine, this theory was abandoned, for it showed that whatever caused the disease must have been normally present in the intestines, very probably as a putrefactive organism.

From a few cases, however (lung Nos. 1, 8, 9; intestine No. 8), swine plague bacteria were obtained, and without doubt the disease was due to these germs. The lung lesions of Nos. 8, 9, and 10 were well-nigh sufficient to make a diagnosis of swine plague, but the existence of intestinal lesions (ulcers in No. 2, 7) without any appreciable disease of the lungs had not yet been encountered in Eastern outbreaks of swine plague, where extensive pneumonic and less frequently pleuritic lesions have thus far proved the only reliable diagnostic sign. The swine plague theory will likewise interpret the negative results of many inoculations. Swine plague bacteria are easily destroyed by drying, in ordinary water, and in putrefactive media. Some of the animals (swine Nos. 4, 5, and 6) had been dead from thirty-six to forty-eight hours, and meanwhile exposed to a temperature below 32° F. Under such circumstances any swine plague bacteria present in the digestive tract may have perished even before the autopsies were made.

Taking these examinations, together with previous work on swine plague in the East, into consideration, we must pronounce the disease not hog cholera but swine plague, basing this inference on the absence of hog cholera and the presence of swine plague germs. The negative results from the cases examined on Farm B are explained by the perishable nature of the swine plague germ, especially in the putrefying contents of the intestinal tract. The following very interesting case certainly favors the theory that swine plague alone was decimating the hogs in that locality:

A gentleman near Mason City, Iowa, had lost during the fall about 45 swine, valued at $800. The last ones succumbed about six weeks ago. Several opened by him had the lungs badly diseased. The intestines were not examined. One of the animals had survived the disease and was now (November 14) to all appearances recovered and in very good condition. The owner, however, was willing to sacrifice the animal, as he believed the lungs diseased. On *post-mortem* examination the abdominal organs were found healthy but the lungs extensively diseased. The left lung was firmly adherent by short bands of connective tissue fibers to the ribs and diaphragm, so that it was well nigh impossible to remove it without considerable laceration. It was shrunken to a small mass, and in its substance were six or seven cavities as large as marbles filled with a soft, pultaceous matter. The walls of these cavities were at least one-eighth inch thick, made up of dense fibrous tissue and stained uniformly on the inside a dark bluish red. The right lung was adherent in several places to the ribs, but contained no abscesses.

This case is chiefly of value in showing that the disease was limited to the thoracic cavity. The infection, introduced most likely through the air passages into different regions of the lungs, caused at the places of deposit pneumonia, resulting in direct necrosis or in cell infiltration (catarrhal pneumonia, broncho-pneumonia) and subse-

quent caseation. The pleura were at the same time involved by extension of the disease process. The animal had recovered from the attack, so far as recovery was possible, with a lung riddled with cavities and firmly bound to the chest wall. It would have been very desirable to determine by inoculation into rabbits whether the cheesy contents of the lung cavities still contained the living germ, but this was impracticable at the time.

Some additional statistics on the spread and severity of the same epizootic around Mason City were kindly furnished by Mr. L. M. Van Auken. On December 1, the first farm north of the one designated as Farm C in the preceding pages was overtaken by the disease. Of 14 old hogs and 62 shoats, weighing from 150 to 220 pounds, 2 old ones and 24 shoats succumbed up to the second week in January. The animals when overtaken by the plague were kept in a yard of about 1 acre and fattened on soft corn. A farm north of the latter was subsequently infected. After 5 or 6 had died the rest were shipped. One of the dead animals was examined by the owner, and the lungs said to have been very badly diseased. Other herds in the same vicinity were swept away at nearly the same time.

Most of these farms were visited by the plague for the first time last fall. The disease is said to have been introduced through hogs taken from the stock-yards in January, 1888. The disease seems to be as virulent as hog cholera, and is to be dreaded as much as the latter disease, considering the rapidity and certainty with which it spread from one place to another and the high percentage of mortality, amounting in many farms to 100 per cent.

SOME OBSERVATIONS ON THE BIOLOGY AND PATHOGENIC ACTIVITY OF THE SWINE PLAGUE GERM FROM IOWA.

In form this organism does not differ from the swine plague bacteria obtained from various sources, East and West, since 1886. In the tissues of rabbits, when these succumb within one or two days, the germs appear as polar-stained bodies. In other words, when stained in dried films on cover glasses, the oval germs have both extremities deeply stained, while the central transverse portion or band is nearly colorless. The reader is referred to the reports for 1886 and 1887 for further details concerning the form of this germ. In those rabbits which do not die in so short a time, and in which the disease develops into a peritonitis (when inoculation is practiced on the thigh), the germs, although exceedingly abundant in the peritoneal exudate, do not all show this polar stain. They resemble solid micrococci more nearly. Their identity with the polar-stained forms is easily settled by cultivation and inoculation into fresh animals.

In cultures the germ is non-motile. It grows especially well in beef peptone *agar* at 37° C. In bouillon, with or without peptone, it grows very feebly, barely clouding the liquid. On the surface of boiled potatoes no growth takes place as a rule, even when kept in a moist atmosphere of 37° C. Only once was a faint development observed with the naked eye. The growth was smooth, pure white, or faintly cream color. In order to detect its presence it was necessary to catch the reflection of the light at a certain angle. This positive result among so many negative ones may be due to differences in the chemical reaction of the potato used. Growth in gelatine at the temperature of the room took place in some instances, in others it failed, so that it could not be depended upon and *agar* was used

almost exclusively. Its resistance to drying was tested with the aid of methods detailed in former reports. Cover glasses sterilized by heat and placed under a sterilized, inverted, and plugged funnel received a little of the growth on *agar* or bouillon peptone. A few hours suffice to dry them out thoroughly. Twice a day cover glasses were dropped into culture tubes containing bouillon to note any multiplication that might take place. The dried germs from *agar* cultures were capable of multiplying in the bouillon up to the sixth or seventh day. Bouillon into which cover-glasses were placed after that time remained uniformly clear. When dried bouillon cultures were tested in the same way the germs were found to be dead after thirty-six hours. It seems, therefore, that germs massed together, as in *agar* cultures, can withstand destruction by drying longer than those desseminated in liquids. While the former lived in the dried state about six days, the latter lived only one and a half days. The same curious fact has been determined with reference to hog cholera bacilli. Thus in a recent laboratory experiment hog cholera bacilli from bouillon peptone cultures lived thirty-six days in a dried condition; those from *agar* cultures twenty days longer.

Pathogenic properties.—As in biological characters so in pathogenic power, the Iowa germ seems to agree with the swine plague bacteria of former investigations. Its effect upon rabbits has been detailed in the preceding pages. Briefly it may be said to produce in them suppuration and hemorrhagic lesions in the subcutis and in the peritoneal cavity. More rarely it produces a true septicæmia, which must be regarded simply as a heightened effect.

Their pathogenic effect on pigs was tried in various ways by hypodermic, intra-thoracic, and intra-abdominal injection of pure cultures.

December 1, one pig, about five and one-half months old (No. 88), received subcutaneously into each thigh 5 cubic centimeters of a bouillon peptone culture derived originally from Iowa pig No. 8. No result.

At the same time No. 86, of the same age, was inoculated into the lungs; 9 cubic centimeters of a culture from the same source was injected through the chest wall into the right lung with a hypodermic syringe having a needle about 3 inches long. The skin at the place of injection was first disinfected with $\frac{1}{10}$ per cent. solution of mercuric chloride.

The pig was found dead next morning. At the autopsy the superficial inguinal glands were found with reddened cortex, the spleen large and gorged with blood. One or two ounces of slightly cloudy serum in the abdominal cavity; a few threads of fibrin stretched over the ventral surface of intestines. The meso-colon attaching the two middle loops of colon deeply reddened; the glands of meso-colon and cæcum also deeply congested throughout the parenchyma. The mucosa of the colon slightly reddened; the large patch of follicles near the valve considerably reddened. Gastric glands with cortex and more or less of parenchyma reddened.

In right pleural sac 2 to 3 ounces of blood-stained serum; none in left side. The entire pleural lining of the right side reddened and covered by a very delicate network of exudate, which is easily scraped together into a soft, pulpy, yellowish mass. Both lungs collapsed, but considerably congested.

In the pleural exudate and in the parenchyma of the right lung are large numbers of polar-stained bacteria. In the spleen an immense number of the same organisms are present. In cultures obtained from this organ they are identical with those injected on the preceding day.

This experiment shows the different effect of inoculation, under the skin and into the thorax, of the same quantity of culture-liquid. While there was no effect from the former, the latter caused an acute septicæmia fatal in less than twenty-four hours.

A second experiment was tried in order to obtain, if possible, the lung disease as found in spontaneous cases.

December 6, two pigs (Nos. 43, 47) were inoculated into the thorax as already described, No. 43 receiving 1½ cubic centimeters of a bouillon-peptone culture originally derived from Iowa pig No. 1, and No. 47, 3 cubic centimeters of the same culture liquid.

No. 47, inoculated at 8 a. m. Temperature on the following day, 4.30 p. m., 105° F. Ate nothing during the day. Respirations labored, abdominal. December 9, temperature, 104⅘° F.; scarcely able to stand; respirations accompanied by a groan. December 11, temperature, 102⅘; very weak and failing until killed December 11. At the autopsy the spleen was found small, pale. Abdominal organs and lymph glands in general normal.

The right pleural sac contains a considerable quantity of blood-stained serum. The pleura of the lungs, the diaphragm, and the chest wall of the side highly inflamed, thickened, and covered by a thick, loose, and spongy exudate, easily scraped away. The ventral lobe of the right lung is solid, the hepatization dark red ventrally, with 5 or 6 lobules necrosed and of a pale-yellowish color. Dorsally in the same lobe the necrosis is more extensive and very likely represents the region where the needle entered the lung tissue. On epicardium a thick, soft deposit, the pericardium much thickened. The left lung normal, but adherent in several places. Of six cultures on *agar* made from the pleural and the epicardial exudate all but one are pure cultures of a germ identical with the injected swine plague bacteria. Of three cultures from the spleen one remained sterile, the remaining two contain only swine plague bacteria.

If this animal had been permitted to live longer the lesions would without doubt have been more extensive in the lung tissue itself. As it was, they are sufficiently severe and characteristic to prove the pathogenic power of the bacteria injected.

No. 43, which received but 1½ cubic centimeters (about one-third dram) of the same culture, showed signs of disease immediately by remaining quiet, refusing food, and breathing laboriously. Five days later, temperature still above normal (105⅗) From this time on it became somewhat better; its appetite returned in two weeks. It did not fully recover, however. One month after the inoculation it was generally unthrifty with staring coat and enlarged abdomen. It was killed January 23. The abdominal organs were normal. In the thorax both lungs were found everywhere adherent to the chest wall and diaphragm by a continuous mass of fibrous tissue not yet very firm. The lungs themselves were not diseased. The pericardium, however, was very much thickened, and when slit open a mass of white cheesy pus was found under it, entirely encircling the heart near the base. About 12 cubic centimeters of this cheesy mass was removed. The inner surface of the thickened pericardium was dark, bluish red. Without doubt the needle, instead of penetrating the lung tissue, had entered the pericardial sac and deposited a portion of the culture liquid in it, converting it into a veritable abscess cavity. Two *agar* tubes inoculated from this pus contained a moderate number of colonies which proved to consist of swine plague bacteria. They had thus remained alive one month and a half.

In order to observe the pathogenic effect that might be exerted by this germ when deposited in the abdominal cavity two pigs (Nos. 138, 139) received 5 cubic centimeters and 2½ cubic centimeters, respectively, in this situation. The material used was a bouillon-peptone culture twenty-four hours old, made from *agar* culture originally derived from Iowa pig No. 9. The result was negative so far as any severe effect was anticipated. No. 138, inoculated December 27, remained very quiet for several days, and could only be made to get up with difficulty. At the end of the third day the temperature was 105° F. At the end of the week it had nearly recovered.

No. 139 showed the same symptoms at first, but recovered more rapidly and was apparently well in five days after inoculation.*

*Recently an abdominal injection from *agar* cultures derived from pig No. 8 (Iowa) produced intense peritonitis, pleuritis, a *croupous exudate* on the mucosa of nearly two-thirds of small intestines, and an intense reddening of the mucosa of the large intestine.

NOTES ON TWO OUTBREAKS OF SWINE DISEASE IN VIRGINIA AND MARYLAND.

Virginia.—On a farm near The Plains, Va., an infectious disease appeared among the swine in October. There were on the farm at that time about sixty-five shoats, from three to five months old, weighing 60 to 100 pounds each. The disease was at its height in November, and disappeared at the end of the year. Up to this time about forty-three had succumbed. The pigs were born on the place, and had been running in a large range following the cattle until the disease appeared, when they were penned. They died so rapidly that they were all turned out again.

The origin of this disease is very obscure. The past history does not give any clew to its introduction. During the great swine epidemic three years ago this farm was not spared, but since then it had been free until January, 1888, when out of a lot of forty similar shoats seven died. Some of this lot were still on the farm at the beginning of the present outbreak. That the January outbreak was due to an infectious disease seems hardly probable considering the small number that died. At time of the last outbreak the disease did not exist in the neighborhood. No swine had been brought upon the farm for five years. There was no evidence of infection from streams, since the farm is situated on a water-shed. The feed is likewise grown on the farm.

Information of this outbreak was received more than a week after the last shoat had died. Dr. Kilborne visited the farm January 9, at which time these facts were made known to him. Two of the convalescents were killed and the lungs brought to the laboratory, they being the only visibly diseased organs.

On inquiry the following general facts concerning symptoms were obtained: No redness of skin on trunk or ea. s. Rapid emaciation with tucked-up appearance of abdomen; frequent prolonged coughing almost to suffocation. Of the two killed, one had been sick for six weeks, but was now partly recovered and in good flesh. There were no lesions of the abdominal organs. The thoracic organs, however, showed traces of a severe inflammation. The pericardium was extensively adherent to the heart muscle by short fibers and the latter covered by a thin layer of newly formed fibrous tissue. Both lungs were more or less adherent to ribs and diaphragm by strong fibrous bands. The most conspicuous thing was the enormous enlargement of the glands at the root of the lungs (tracheal, bronchial). They appeared like a bunch of large grapes of a bluish-red color. On section the cortex appears as a red line, and similar lines pass through the parenchyma, which has a pale lardaceous appearance. The lungs are about twice the collapsed size, very flabby, the various lobes bound together by short firm fibers.

A large portion of the principal lobe is airless, of a pale red-color on section, and œdematous. The bronchi have their walls thickened (peribronchitis). The remainder of the lung tissue is in practically the same condition. The large air tubes have the mucosa covered with a layer of glairymucus, the small vessels injected.

One of two rabbits which received ¼ cubic centimeter of a hypodermic injection of lung emulsion died in four days, with extensive pasty thickening of the subcutis of thigh, discoloration of subjacent muscles, gelatinous exudate over the groin and on musclesof abdomen. In the latter cavity the cæcum and contiguous portion of colon are covered with minute subserous hemorrhages. The exudate is slight, covering in part the inflamed intestines and the liver, viscid so as to be drawn out into thin threads when coils of intestine are lifted up. Very many coccus-like germs in this exudate, very few in blood and spleen. In an *agar* culture from the blood fertile. In all respects the germ is identical with that of swine plague.

A rabbit inoculated from the *agar* culture of the first rabbit indirectly, by injecting subcutaneously $\frac{1}{12}$ cubic centimeter of a bouillon-peptone culture made from it died in four days with substantially the same lesions, excepting that the thigh muscles were more extensively discolored.

The second rabbit inoculated from the lung tissue of the pig died in eight days. The lesions of this animal were of the same character but less severe. The hemorrhages on the intestines were absent, though the exudate was abundant. From the blood two *agar* tubes were inoculated; both developed an abundant growth of the same bacteria (swine plague) obtained from the first rabbit.

The condition of the second pig when killed was like that of the first. The abdominal organs were normal. The lungs were free from adhesions. Throughout all the lobes of both, but especially along the free short margins of principal lobes, are masses about the size of a marble, or in a thin layer under the pleura, of a waxy, semi-translucent aspect, on section solid. The remainder of the lung tissue œdematous.

Two rabbits were inoculated from lung tissue. Of these, one died on the fourth day. There were no lesions to account for death; no germs in the various cultures from its organs. The second rabbit remained well.

From the spleen of each pig three *agar* tubes were infected with bits of spleen tissue. The three cultures made from the second pig remained sterile. Two from the first also remained sterile. In the third tube a germ like swine plague appeared which failed to develop when transferred to fresh tubes.

It is highly probable that the outbreak was swine plague, although the presence of swine plague germs in one case can not be regarded as conclusive evidence. It is remarkable that these germs should still be present in an animal almost recovered from the disease.

Maryland.—The cases reported below were very likely affected with hog cholera, although the bacteriological examination, as far as it went, gave negative results. It seems reasonable to suppose that when swine roam over a considerable extent of territory in search of food the virus is more widely distributed but less concentrated. Less virus is therefore taken up by individual animals, and although the disease is equally fatal in the end, the course may be somewhat different and the lesions less extensive. At the same time the bacteria may elude observation. They may remain more or less localized, owing to the reactive power of the organism, which destroys those that have entered the internal organs. To those who would give up the search for hog cholera bacilli after a few unsuccessful attempts to find them we would recommend the perusal of the following three cases:

Swine diseases prevailed more or less in Montgomery County, Md., during the latter weeks of September and the early part of October, 1888.

October 17.—Mr. H——— lost about twenty-two out of a herd of fifty-five to sixty swine during the past four weeks. Of those now scattered in a large field two appear ill; one, a small black shoat, is killed by cutting its throat, and examined. The superficial inguinal glands are very much enlarged, the surface mottled, dark red; the spleen large, but pale and rather firm. The liver shows signs of invasion of the *Sclerostoma pinguicola*. The lymphatic glands at lesser curvature of stomach are very large; cortex completely hemorrhagic.

The left lung normal; the principal lobe of the right lung has in it a mass of tissue involved in broncho-pneumonia, extending obliquely from the free border to near the dorsal region, about 1 inch thick. The lymphatics along the dorsal aorta are likewise hemorrhagic; the stomach filled with food; small intestines contain a number of attached *echinorhynchi;* the large intestines distended with semi-solid fecal matter. The mucosa, in general, is normal, but in the cæcum are two ulcers about three-eighths of an inch across, round, slightly elevated, with center black and periphery yellow. Beneath the superficial slough is a whitish, firm, new growth, extending to the muscular coat in the center of the ulcer.

The spleen and the right lung were taken to the laboratory. From the former cultures were made on *agar*, in gelatine and beef infusion, by adding bits of spleen tissue as large as peas. In no tube did any development take place. A rabbit inoculated by tearing up a pair of hepatized lung tissues in sterile beef infusion and injecting the turbid liquid subcutaneously remained well.

Several miles from the first farm we came upon a herd of young pigs which were just showing signs of disease, although none had been lost. One of them, with unsteady gait, which hid in the litter under a shed and returned to it when driven

away, was killed by bleeding from the vessels of the neck. The lungs were without a sign of disease. Spleen enormously enlarged and gorged with blood. The lymphatic glands of groin and about stomach very large, but rather pale, and œdematous on section. Stomach filled with food. Large intestines overdistended with very dry, hard feces, somewhat softer near cæcum; in the latter only one ulcer, and this on the valve about one-fourth of an inch across, and of the same nature as the one found in the preceding case.

A portion of the spleen of this animal was taken to the laboratory and cultures made as in the previous case, with bits of spleen. All cultures remained permanently sterile.

Several miles from the latter place we found the disease on a farm situated on a hill. The swine were allowed to go a considerable distance down the slope to a marshy stream. The owner had lost 6 or 8 out of a herd of 20 to 25 within six weeks. A few were evidently ill, but none were killed, as a dead one was found. It had probably died during the night. The buzzards had consumed nearly all the intestines through a small hole near the pubis. Putrefaction had already set in. Spleen enlarged, slightly congested. In the small portion of the large intestine, which still remained, an ulcer was found three-eighths inch across. The glands or lesser omentum with hemorrhagic cortex. The stomach contains a small quantity of bile-stained fluid. Both lungs glued to chest wall by coagulated fibrin from blood extravasation. Left lung contained about ten to fifteen hemorrhagic foci, visible under pleura, one-fourth to one-half inch across. The principal lobe of right lung solid, granular, evidently broncho-pneumonia. The hepatized lobe was discolored by recent and extensive blood extravasation. A gelatinous deposit under sternum resting on pericardium. The semi-decomposed condition of the animal prevented a more careful examination. Portions of the spleen and hepatized lung tissue were taken for examination.

While the spleen of the two preceding cases showed no indications of bacterial life on cover-glass preparations, the spleen of this case contained a considerable number of bacteria resembling hog cholera bacilli very closely. On gelatine they grew differently from the latter, and the cultures emitted a slightly offensive odor. In liquids they were actively motile. They were putrefactive bacteria, without effect upon two rabbits inoculated with large quantities of the cultures. A rabbit inoculated with the diseased lung tissue remained well. The latter, on closer examination, had a texture as granular as the roe of fishes, the granules being inspissated cell masses in the alveoli and air-tubes. At least four different kinds of bacteria were present in large numbers.

The absence of specific disease germs from the spleens of these pigs is in harmony with the results obtained in other infectious maladies when animals are killed in the early stages or during the height of the disease. It is only in the last stages that the bacteria are able to multiply and appear in sufficient numbers in the internal organs to be detected. In the third case, death was very likely brought on by the pulmonary hemorrhage not infrequently found in hog cholera. The specific bacilli produced at first the ulcers, and were either working their way slowly into the internal organs or else were being destroyed in the ulcer itself. The latter termination would signify recovery, the former death. These ulcers might be aptly compared to the malignant pustule in man, in which the virus remains at first localized but may spread throughout the system after a time. The presence of numerous ulcers in swine is to be regarded as a multiple infection, while in the three cases just cited the infection was limited to a few foci or but one. The ulcers would no doubt have revealed the virus, but our previous experience with the spleens of diseased swine made it seem unnecessary to study the ulcer itself. As regards the lung disease of the third case nothing positive can be said. It resembled most closely chronic swine plague. The germ of this disease was not present, however, as shown by the rabbit inoculation.

THE ETIOLOGY AND DIAGNOSIS OF GLANDERS.

Glanders is a contagious disease of importance, both from an economical and sanitary stand-point. It is not only communicated from one horse to another, but it is occasionally transmitted to man, producing a severe and generally fatal disease.

The consensus of opinion and of legislation to-day demands the slaughter of animals affected with glanders. Recovery of horses affected with this disease is perhaps never complete. In the great majority of cases it runs a course of variable length, the final result of which is death preceded by emaciation and general debility. Nor is there any remedy or cure for the disease. Granted even the possibility of recovery, the affected animal is in the meantime a source of continual danger to other horses and to human beings. It is therefore in the end economy to immediately destroy glandered horses when detected, even were human life not endangered by their presence.

But the diagnosis of glanders is not always an easy matter. It may be confounded with a number of other diseases, and when a very valuable animal is involved an accurate diagnosis is of great importance. Since the discovery of the bacillus of glanders in 1882 considerable attention has been paid to the matter of diagnosis, and we are in a position to-day to present a few valuable facts in this connection. In the following pages some space will be devoted to the consideration of the causation or etiology of the disease, with special reference to the specific bacillus and its biology, a brief account of experiments made both in our own laboratory and elsewhere to facilitate diagnosis.

ETIOLOGY.

The communicable nature of the disease among horses known as glanders and farcy is now thoroughly established by experiments, which have revealed its cause as a micro-organism belonging to the group of bacilli. These experiments date from the year 1882. The contagious character was, however, recognized long before this time and various experimenters had succeeded in producing the disease in horses and other animals by inoculating with the nasal discharges and other pathological products of the disease. In Germany the real character of glanders was recognized as far back as the first quarter of the present century. In France, however, there was a strong opposition to those who held glanders to be a communicable disease, which opposition was not overcome until about thirty years ago.

Various efforts had been made in the last forty years to discover the actual cause of the disease, either in the blood of the affected animal or in the specific lesions of the air passages and the skin. The alleged discoveries in most cases were far from the truth, and at times sensational and absurd. Thus Hallier, in 1868, claimed to have found the same organism in glanders which he regarded as the cause of syphilis in man. The doctrine that syphilis originated in glanders had been promulgated before this, and was now seemingly confirmed by Hallier's fantastic inferences. In 1882 Roszahegyi described organisms which he found in the pustules of a man who had succumbed to acute glanders. His description warrants the belief that he was

the first to see the bacilli of glanders. He did not go far enough, however, and failed to show any causal relation between these organisms and the disease. In 1882, Löffler and Schütz published the first positive results obtained in isolating the bacillus of glanders, which have been confirmed by a number of observers subsequently. Meanwhile work had been going on in France in the same direction. Bouchard, Capitan, and Charrin published in 1883 the results of cultivation and inoculation experiments dating back to 1881, which they claimed as decisive in demonstrating the microbe of the disease. A careful perusal of Bouley's note to the Academy of Medicine in 1883 (*Bull. Acad. Médecine*, 1883, p. 1239) will, however, convince any unbiased reader that the methods which they employed (in one case they made cultures from a nasal ulcer in bouillon, in another from a spleen tubercle in bouillon) are either unsafe or insufficient in bringing about any positive results as to the true nature of the specific microbe. We must therefore accord to Löffler and Schütz the credit of being the first to have demonstrated in a satisfactory manner the presence of a certain microbe in glandered horses and its capacity of producing the disease in healthy horses. A brief résumé of their work* will serve at the same time as a description of the bacillus as they found it in the lesions and in cultures, and as an introduction to the work done on the same subject in the laboratory of the Bureau.

The authors found considerable difficulty in demonstrating the presence of glanders bacilli in sections of nodules in the spleen and liver of glandered horses, owing to the fact that most of the staining agents failed to color them. Finally, the following solution was made, which now goes under the name of Löffler's stain: 30 cubic centimenters of a concentrated alcoholic solution of methylene blue was added to 100 cubic centimeters of .01 per cent. potassium hydrate. When sections were placed in this deep-blue liquid for about 5 minutes, transferred to a 1 per cent. solution of acetic acid for a few seconds, then dehydrated in alcohol and cleared in cedar oil, very delicate bacilli could be detected now and then, especially near the periphery of young nodules. As a rule they were very rare ,but no other organisms were found.

Löffler recommends for the study of bacilli of glanders, both on cover-glass preparations and in sections, very recent nodules from the lungs of inoculated guinea pigs, as they are quite numerous in this situation. For cover-glass preparations he found the following solution to give the best results: Aniline water gentian violet,† or fuchsin is mixed with an equal volume of .01 per cent. caustic potash, or ½ per cent. liquor ammonia, directly before using. The cover-glass preparation ‡ is stained by floating the cover-glass with the film down

*The full publication of their experiments will be found in *Arbeiten a. d. Kaiserlichen Gesundheitsamte*. Berlin, 1886, I, p. 131, and their preliminary report translated in volume 95 of the New Sydenham Society, 1886.

† This stain, used in the study of tubercle bacilli, is made by shaking up 5 cubic centimeters of aniline oil in 100 cubic centimeters of water and filtering. To the filtrate is added 11 cubic centimeters of a concentrated alcoholic solution of the aniline dye to be used, in this case either gentian violet or methyl violet or fuchsin.

‡ Prepared by crushing the nodule between the ends of forceps and rubbing it in a very thin layer on the cover-glass. When thoroughly dry it is seized with the forceps, drawn three times through the flame of a Bunsen burner, the film side being held up or away from the flame. Pus from abscesses is rubbed in a very thin film on cover-glasses and treated in the same way.

on the staining fluid for about five minutes. It is then dipped for a second into 1 per cent. acetic acid to which a watery solution of tropaeolin .00 * has been added until a wine-yellow color is obtained, and then washed in distilled water, after which operation it may be examined or mounted in balsam for preservation.

From the nodules and tubercles in the liver, spleen, and lungs the contained pus was used to inoculate tubes containing various culture media, both liquid and solid. A special value was put upon those lesions which do not in any way come in contact with the external air, such as those in the spleen and liver. Within three days the surface of those tubes containing blood serum appeared as if sprinkled with minute yellowish, translucent droplets. These droplets were made up of very delicate rods or bacilli, varying in length between one-third and two-thirds of a red corpuscle. Their width was from one-fifth to one-eighth of their length. They were either straight or slightly bent, with rounded extremities, and in general somewhat shorter and thicker than tubercle bacilli. In liquids they manifested active Brownian movement, but true spontaneous movements were never observed. They were without doubt identical with the delicate rods observed in sections under the microscope.

Of the biological character of bacteria, their growth or multiplication outside of the body on various substrata is very important, for by this means of so-called cultivation we can determine how far they are capable of growing in our environment and thus keep up the infection, between what temperature limits multiplication may take place, also whether any resistant spore state is entered upon during their life. There is still another advantage to be derived from cultivation—one which mainly concerns us now—the ability on our part to diagnose between one organism and another by characters of growth discernable with the unaided eye. The bacilli of glanders have certain features in cultures which are of great use in distinguishing them from other organisms.

They grow very well on blood serum from horses and sheep, less abundantly on that from cattle. On the third day after inoculation of such media, minute droplets of a translucent yellowish color appear on the surface of the serum. These droplets or "colonies" consist entirely of bacilli which have descended from perhaps a single bacillus originally deposited there. The material composing the droplets is of a viscid consistency, and may be drawn out on the platinum needle into thin threads. After eight or ten days this yellow translucency is replaced by a milky opacity.

A very good soil for the multiplication of these bacilli is the cut surface of boiled potatoes. Löffler and Schütz describe the very characteristic appearance substantially as follows: Already on the second day the surface of the potato is covered with a delicate yellowish, translucent layer, which becomes amber colored later on. After six or eight days a reddish color appears; the transparency is lost and the color suggests the red of cuprous oxide. The potato surface bordering the growth assumes a pale greenish appearance. This description applies very closely to the potato cultures made in the laboratory of the Bureau. A very striking appearance is produced when bits of tissue are used to inoculate the potato, since the bacilli not being very numerous, the colonies appear isolated instead of being fused into a uniform layer. They are exceedingly small at

* This is not essential.

the beginning of the third day, scarcely recognizable. Towards the end of the third day, the cultures being kept at 37°C., the colonies are visible as minute hemispherical masses of a delicate translucent, pale-yellow tint. In fact the cut surface of the potato appears as if sprinkled with a pale-yellow serum. Gradually the color changes as above described and the colonies fuse into an opaque layer.

The probability of a multiplication outside of the animal organism of glanders bacilli is very slight. Experiments have shown that they do not develop when the temperature is less than 25° C. (77°F.), and then only on certain substances, such as boiled potato, blood serum, *agar-agar* with peptone. When infusions of hay, straw, oats, wheat, and manure, such as form in and around stables, were inoculated with glanders bacilli no multiplication took place even at the most favorable temperature. Owing to the high temperature necessary for this multiplication gelatine can not be employed as a culture medium.

It has already been stated that glanders bacilli have no movement of their own. This I can confirm from numerous observations. Only the slight dancing movement observed among all bacteria suspended in liquids could be detected. There seems to be a difference of opinion, however, on this important point. In Eisenberg's *Bacteriologische Diagnostik* they are characterized as actively motile, and this statement is repeated in a second edition recently issued. If this difference of opinion depends on a difference in interpretation of the same object, it is high time that bacteriologists define clearly what is meant by motility.

My own observations differ from those of Löffler and Schütz in regard to its growth in liquids. They state that in neutralized bouillon prepared from muscular tissue of man, horse, sheep, rabbit, beef, and fowl, with or without 1 per cent. peptone, it multiplies very well. At the end of the second or third day the liquid becomes clouded, and finally a viscid, whitish deposit forms. Our observations extend only to cultures in slightly alkaline beef infusion peptone. These have never shown a perceptible clouding. The liquid remains limpid, and one might say after a short inspection of the tubes that there was no growth. When vigorously shaken up, however, a yellowish-white deposit is seen rising from the bottom as a twisted column when the culture is one or more weeks old. This very viscid mass consists of glanders bacilli. It is probable that by varying the reaction of the liquid slightly, or the meat employed, a fluid medium may be obtained in which the bacilli of glanders as found in our country may grow like those studied in Berlin. At all events, so far as my experience goes, I should feel very suspicious of a bouillon culture of glanders which became clouded in two or three days after inoculation.

Glanders bacilli change their form more or less in cultures as the latter grow older. This is without doubt a degenerative process, and the changed bacilli are dead or nearly so. True rod forms are seen in sections of tissues and in very young cultures only. In older cultures they no longer appear as true rods, but the change of form is not easily made out, owing to the minuteness of the objects under examination. A frequent form is that of an oval and even a coccus, in which the stained area is limited to one side or frequently to the two poles, leaving an intervening clear space, which has been described by some observers as a spore. It has no refractive power,

however, and can only be considered an empty space in the interior of the bacillus. Other degenerative or involution forms, giving rise to the appearance of a chain of cocci, are now and then observed. It must not, therefore, be inferred that cultures of glanders bacilli are necessarily impure when very few slender rod forms are met with.

DIAGNOSIS OF GLANDERS.

The foregoing brief description of glanders bacilli and of their cultures is of great service in diagnosis. Cultures made from the spleen or liver tubercles of slaughtered horses, exhibiting the characters already described, would prove beyond a doubt that the animals had been affected with glanders. But veterinarians in most cases are able to make a diagnosis on *post-mortem* examination without the aid of cultures. The question to-day is whether glanders can be positively diagnosed in the living animal, especially when the gross appearances of glanders are obscure and the animal is a valuable one.

If cultures of the specific bacilli could be obtained directly from the living animal the problem would be very simple. Those accessible organs or parts of the horse which may be the seat of disease are the nasal passages, the submaxillary glands, and the skin or subcutaneous tissue. Frequently only one of these parts is involved. But it is impossible to make cultures from the nasal ulcers or discharges because they contain, besides the specific bacilli, many other bacteria. In tubes inoculated from such material a single day would suffice for the rapid multiplication of the other bacteria so as to entirely crowd out or bury up any glanders bacilli that may have been present; as the former grow many times more rapidly. When nodules are present under the skin it is highly improbable that the bacilli can be obtained therefrom in pure cultures during the life of the animal, owing to the danger of contaminating the cultures. When the nodules have once broken down into ulcers numerous other bacteria lodge in them, and cultures are then out of the question. It has been suggested recently that the enlarged submaxillary glands be removed and examined for glanders bacilli. Thus far we do not know in what numbers they are present in these enlarged glands, and it would require considerable preliminary study to determine whether cultures are successful when made from them.*

The direct determination of glanders by means of microscopic examination and cultivation is thus far not feasible.

The question might be asked, Why not isolate the glanders bacilli from the impure discharge from the nose, or from ulcerated farcy buds, as we should do in searching for the comma bacillus in the bowel discharges of Asiatic cholera? This might unquestionably be done, but it would be a very tedious method, requiring much minor apparatus and still more patience, and in the end the result might be negative. The reasons for this are various. Glanders bacilli do not grow in gelatine at the temperature at which plate cultures can be used. *Agar* plates might be used, but germs grow upon *agar* very much alike, and as glanders bacilli are, as a rule, very scarce in discharges, the labor of examining microscopically a large number of colonies to find the right one would become very great. Finally, they grow very slowly, and would be in danger of being overrun by the colonies of putrefactive germs which grow very rapidly in the thermostat.

*See the end of this chapter with reference to this point.

Cadeác and Roy (*Journal de Médecine Vétérinaire*, May, 1888) made cultures on potato directly from the nasal discharges of various animals, and claimed from the similarity of the color of the growth from these different sources to cultures of glanders bacilli that this method of diagnosis is of no value. The authors have entirely mistaken the method. Neither Löffler nor any other subsequent German observers have maintained that cultures made on potato from the nasal discharges or any other product in contact with the air have any value whatever. The fundamental principles of bacteriology are directly opposed to the indiscriminate cultivation of a number of germs on the same substratum, and especially the potato. Only those disease products which have not yet been exposed to the air, or which are buried in the depths of vital organs, can be used for cultivation.

The method which is now in use more or less, and which was perfected by Löffler and Schütz, consists in inoculating small animals, more especially guinea-pigs, with the disease products. These in turn develop the disease, the nature of which may then be determined by the lesions of the inoculated animals, both internal and external, or more positively demonstrated by cultures from the various organs. In this method the animal body becomes, so to speak, the culture flask, and a very perfect one, too, for it not only permits the disease germs to multiply in the various organs, but it also speedily destroys all other germs inoculated at the same time, leaving the glanders bacilli in entire possession of the field.

The inoculation of species of animals other than the horse and ass, which are naturally susceptible to this disease, has been tried by many investigators. These experiments need not be recounted here, as they are not pertinent to the subject under discussion. They have shown that cattle are insusceptible; that goats and sheep may take the disease after inoculation, the former even spontaneously. Lions and tigers in menageries have contracted glanders by feeding upon the raw flesh of glandered horses. Cats contract the disease in the same way and are susceptible to inoculation. Dogs are less susceptible than cats, both when fed and inoculated. Coming to those smaller animals which might serve a useful purpose in making a diagnosis, we also find great variety in the relative susceptibility. Among those which have been tried are rabbits, guinea-pigs, white mice, white rats, field-mice (*Arvicola arvalis* and *Arvicola terrestris*), pigeons, fowls, and several other rodents. Of these the white mice, white rats, and fowls were found practically insusceptible; the rabbits varied in this respect; some contracted the disease after inoculation, others did not. Guinea-pigs and field-mice proved to be uniformly susceptible when inoculated, both with material directly from the animal and with bacilli from cultures.

The course of the disease and the lesions produced in guinea-pigs are well described by Löffler. As a place of inoculation he chose one side of the abdominal surface, about half way between the axilla and the groin. The hair was carefully cut away, a fold of skin raised and cut through completely with scissors. Into this incision, about two-fifths inch long, a flamed needle was introduced and moved to and fro under the skin, to form a little pocket for the reception of the infectious material.

At the place of inoculation an ulcer forms during the first week, with suppurating base and thickened border. Towards the end of the first week the nearest lymphatic glands, in this case those near the groin, begin to enlarge. The lymphatics themselves do not,

however, swell into cords, as is true of farcy in the horse. The glands grow to the size of hazel-nuts, sometimes larger, and their contents soften into a puriform mass. The capsule as well as the skin over it may rupture and the contents discharge on the surface. When this takes place early, numerous glanders bacilli are found in the discharged pus. In some animals the disease may stop here and the ulcer heal. The primary ulcer usually heals in from two to three weeks. The guinea-pig after four to six weeks may have entirely recovered. In the majority of guinea-pigs, however, the disease ends fatally. In the second week the testicles of the male contain hard, nodular places. Inflammation sets in, the overlying skin becomes red and œdematous, and finally breaks. Puriform masses, containing numerous bacilli, are discharged. In females the labia and mammæ more rarely inflame and suppurate. At about the same time one hind or fore foot may begin to inflame, swell, and give rise to great pain on pressure. Sometimes the inflammation may leave one foot and appear in another; more rarely all feet may be affected. They may also become ulcerated, but as a rule the death of the animal ensues before this takes place. Besides these characteristic changes in the feet and testicles, there may be nodules in and under the skin in different regions of the body which may also break and form ulcers. In the face these nodules start from the periosteum, or even the bone itself. The mucous membrane of the nose was involved in only one-third of the eighty-five cases studied by Löffler. The disease process was first noticed at about the same time with the swellings of the feet, and manifested itself by difficult breathing and sneezing. The secretion is scanty and dries up into brownish crusts around the external nares. This lesion is speedily followed by emaciation and death, which usually takes place in the third or fourth week, sometimes as early as the second and as late as the eighth week.

At the autopsy the place of inoculation may be occupied by an ulcer or healed and cicatrized. The inguinal or axillary glands are swollen and contain small abscesses, or the whole gland may have been converted into pus inclosed in the gland capsule. In the skin are abscesses as large as peas or hazel-nuts, in part healing. One or more feet are swollen. The swelling may be due to a periarticular abscess, to inflammation of the joint itself, or of the ends of the bones forming it. The lungs usually contain a variable number of small grayish-yellow nodules, situated chiefly under the pleura. In almost every case the spleen is involved. It is enlarged, and contains a large number of minute, slightly projecting, yellowish nodules, some attaining the size of a pin's head. They are frequently found in the liver, though in smaller numbers. In the omentum, the suspensory ligament of the liver, and the retro-peritoneal tissue small abscesses may be found. In the testicles, and more especially the epididymis, the earlier stage of the disease is indicated by the presence of reddish-gray nodules as large as pins' heads. Later on these have been converted into larger, cheesy masses, in some cases broken through the skin. In females the ovaries are rarely involved, more commonly the mammæ. The mucous membrane of the nose is usually reddened and swollen. Small ulcers may be present on the septum and the turbinated bones. The presence of glanders bacilli is determined microscopically without any difficulty when the disease process is recent. When suppuration has set in it becomes more and more difficult.

Löffler also experimented with field-mice (*Arvicola arvalis*), which he found very susceptible to inoculation with cultures. In most cases death ensued from three to five days after inoculation into the subcutaneous tissue near the root of the tail. The spleen and liver were quite invariably crowded with barely visible nodules. Rarely the joints of the feet became diseased. In the lungs and skin lesions were absent.

Kitt,* experimenting upon wood-mice (*Mus sylvaticus*), found them very susceptible to inoculation. When either cultures of glanders bacilli or bits of tissue containing them were placed under the skin of these animals they lived from eight days to one month thereafter. The spleen was very much enlarged, dark red; on its surface and on section were numerous grayish-yellow nodules barely the size of a pin's head. At the place of inoculation there is usually a dry scab, accompanied occasionally with some suppuration or œdema. From the experiments noted by the author it would be difficult to infer how far these mice are of value in making diagnosis from nasal discharges—that is, how far they are capable of resisting septic infection.

In a more recent communication (*Oesterr. Monatsschrift f. Thierheilkunde*, January, 1888), the same author experimented with a species of rat (*Arvicola terrestris*). Of fourteen inoculated with pus from a glandered guinea-pig into the subcutaneous tissue of the abdomen, all died in from four to ten days. There is usually an ulcer formed at the place of inoculation, with enlargement and suppuration of the neighboring lymphatic glands, enlargement of spleen, which contains numerous yellowish-white nodules. Not infrequently grayish nodules are present in the lung tissue. Besides these rats, *Erinaceus Europæus* was also tested with reference to its susceptibility to glanders. Inoculation was uniformly successful. The spleen and lung tissue were the chief seat of the disease, both being infiltrated with tubercles readily visible to the naked eye. But to these animals the same objection applies in so far as they were tested with material containing glanders bacilli only, which does not prove their utility when septic material must be inoculated. Their resistance to septicæmia can only be determined by inoculating the nasal secretion from glandered horses.

In Russia the bacteriological station at Odessa† reports favorably the use of a rodent (*Spermophilus guttatus*) which takes the place of our prairie-dogs in that country, and is closely related to it. Of twenty-eight inoculated sixteen died on the fourth day, nine on the fifth, two on the seventh, and one on the tenth day.

Of these animals, nearly all of them rodents, the guinea-pig is considered the most satisfactory. The other animals are more or less susceptible to septicæmia caused by bacteria present in secretions and discharges in contact with the air. They are therefore liable to die of septicæmia before glanders is developed. At the same time this does not exclude the use of these rodents when guinea-pigs are not to be had, provided a sufficient number, say, at least five or six, are inoculated from the same horse. They would require a careful bacteriological examination to make sure of the nature of the disease. In guinea-pigs, on the other hand, the external signs of disease, such as the swelling and suppuration of lymphatic glands,

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* *Centralblatt für Bacteriologie*, 1887, ii, p. 241.

† Kranzfeld: *Zur Kenntniss d. Rotzbacillus. Centralbl. f. Bacteriologie*, 1887, ii, p. 273.

testicles, and feet, the formation of abscesses and ulcers in and under the skin, and the not infrequent nasal disease, are sufficient of themselves to decide the question without bacteriological evidence. Guinea-pigs very rarely die of septicæmia or putrid changes under the skin as the result of inoculation.

The animals above mentioned are not indigenous in our own country. Dr. C. Hart Merriam has kindly furnished the names of a few American representatives or closely allied forms. *Arvicola riparius*, the meadow-mouse, may be used for *Arvicola arvalis;* for *Arvicola terrestris, A. austerus;* for *Spermophilus guttatus*, *Sp. Townsendi* or *Sp. Richardsoni*, which is common in northern Dakota. Of *Erinaceus Europæus* there is no American representative.

Those who are called upon to make diagnosis of glanders should endeavor to always have a supply of guinea pigs on hand. In order to make the diagnosis of value Löffler recommends that from three to five should be inoculated, and not simply with a prick of the lancet, but larger quantities (a large drop) of the mucus from the nose should be placed in a pocket under the skin, as already described. The greater number survive the inoculation and show positive signs of glanders in two weeks. Males should be used whenever possible, owing to the characteristic lesions of the testicles.

The following experiments were made during the year 1888 with the purpose of determining how far the statements in the preceding pages could be relied upon in making a diagnosis. The great majority of the inoculations were made upon guinea pigs from the nasal discharges of glandered horses. Many of the latter had ulcers on the septum of the nose which could be seen, so that the diagnosis of glanders was made without resorting to inoculation.

I. January 21 two adult guinea pigs (Nos. 1, 2) were inoculated with a lancet, the material being taken from nodules in the lungs of a glandered horse. No result.

II. April 13 two guinea pigs (Nos. 3, 4) were inoculated subcutaneously on the left side of abdomen with nasal discharge from a horse suspected of chronic glanders. Guinea pig No. 3 was found dead May 5. It had for ten days previous nasal discharge. At the autopsy the following lesions were noted: Left fore limb and right hind limb very much swollen. In the right inguinal regions an ulcer with ragged border one-half inch across. The left inguinal lymph gland enlarged and containing several whitish nodules about the size of a hemp-seed. In the nasal passages considerable purulent matter. Spleen enlarged, thickly dotted with very small whitish masses.

From this animal no cultures were made, but two fresh adult male guinea pigs were inoculated each from the spleen and inguinal gland by taking bits as large as hemp-seeds and placing them under the skin. One of them has, on May 20, an open, dry sore, one-half inch across, adjacent to the place of inoculation. The inguinal gland and testicle are considerably enlarged. The skin over the latter is becoming abraded. Some days later the right fore limb was very badly swollen. It was killed June 4.

There were several small ulcers on the surface of the body; the right fore foot swollen. From the spleen cultures were made on *agar*, potato, and in beef infusion. All remained sterile. The other guinea pig recovered. The inguinal gland had been slightly enlarged at one time.

Guinea pig No. 4, inoculated with nasal mucus April 13, showed only slight enlargement of axillary and inguinal lymphatics. May 5, four days later, the right fore leg was badly swollen, and an ulcer had formed on the top of the nose. It was killed with chloroform May 12, twenty-nine days after inoculation. At this time the swelling of fore leg had subsided, the place of inoculation had healed, but the neighboring inguinal gland was one-half inch in diameter. Spleen slightly enlarged, very pale. Liver dark. In neither are nodules discernible. Cultures were made from spleen and the enlarged gland. The hair was carefully clipped away and the skin blackened with a red-hot spatula in the line of the proposed incision. A flamed knife was then thrust into the gland, which was found converted into a soft, white, cheesy mass. The *agar* cultures from spleen remain sterile. Those from inguinal gland contain on the third day colonies of glanders bacilli. On the potato inocu-

lated from the gland about twenty translucent, serum-like colonies appear from 1 to 2 millimeters in diameter. Examination shows them to be made up of glanders bacilli.

Bacilli from this culture, suspended in sterile beef infusion, were injected subcutaneously into a guinea pig on the left side of abdomen May 15. Five days later the testicles began to enlarge, and within three weeks they were both 1½ inches in diameter. The animal was killed June 4. The spleen was slightly enlarged, but without nodules. At the place of inoculation a fluctuating mass under the skin, about one-half inch in diameter, filled with a soft, cheesy, yellowish-white pus. On both testicles were ragged, blackish depressions, as if the skin either had broken or was about to do so. The contents of both were entirely converted in yellowish-white, cheesy pus. From one of them cultures were made, as indicated above. On the third day typical colonies of glanders bacilli had appeared.

III. April 6, two guinea pigs were inoculated subcutaneously with scrapings from the base of ulcers on the nasal septum of a horse killed for glanders. Up to May 10 the place of inoculation had healed in both cases. In one, an inguinal gland and the testicles were enlarging. May 26, this one was killed, as it was growing gradually worse. At the autopsy the left inguinal gland was about one-half inch in diameter, the contents easily expressed as a thick creamy puss. The inguinal gland of the other side about half as large. The left testicle has a broad scar with blackened base, evidently a rupture through which the contents had been discharged, which accounts for the shrunken size of the gland. The other testicle consists of two enormous abscesses, apparently not communicating with each other (testicle and epididymis), containing liquid pus. Between the nose and the right eye an ulcer with a blackish dried-up base and irregular margins. Two days later a potato culture, made from the spleen, contains a moderate number of isolated colonies characteristic of glanders. An *agar* culture did not grow. From one testicle two *agar* cultures contain numerous colonies. From the enlarged inguinal gland both an *agar* and a potato culture developed numerous colonies. These were characteristic, both macroscopically and microscopically, of glanders.

From the potato culture of the inguinal gland, when ten days old, two mice were inoculated by injecting subcutaneously a few drops of a suspension of bacilli in sterile bouillon. Both remained well. The second guinea pig, inoculated from the same horse, did not take the disease.

IV. April 27, a young female guinea pig and a rabbit were inoculated with pus from farcy buds (glanders of the skin). The rabbit remained well; the inoculation wound was healed at the end of two weeks. In the guinea pig the wound had also healed, but the inguinal gland was beginning to enlarge. May 16 the gland was much larger, and the labium on the same side was beginning to swell up. May 20, a swelling about the size of a walnut appeared under the skin above the hip of opposite side. This broke later on. Found dead May 24. Besides the lesions already mentioned both fore feet and the right hind foot were swollen. The contents of the enlarged inguinal gland were puriform. In the labium a small abscess. Cultures were made on various media from the spleen, lymph gland, swollen labium, and blood. Those from the spleen and gland were pure cultures of glanders bacilli; those from labium impure.

From the spleen and inguinal gland of this guinea pig two young male guinea pigs were inoculated May 24, each receiving a minute portion from both sources. June 7 one was killed. Both fore feet are swollen over the carpal and metacarpal joints; the right has a depressed place concealed by a scab. The left hind limb is also swollen over the tibio-tarsal joint. The place of inoculation is covered by a scab. The inguinal gland and testicles are not swollen. The internal organs are not visibly altered. Cultures were only made from spleen pulp on *agar*, which remained sterile.

The second guinea pig recovered.

V. June 4, from the nasal discharge of a horse affected with glanders, two guinea pigs, two young rabbits, and a young dog were inoculated, all in the same manner under the skin, as already indicated. One of the guinea pigs died July 9. It had a large ulcer with black dried-up base behind the left nostril, three on abdomen, and one on the right flank three-fourths inch in diameter. There was also an ulcer on the left heel and right fore limb. The right heel was considerably swollen. The left testicle was also quite large. The spleen was free from nodules. Cultures on *agar* and potato were made from the spleen only. These were found subsequently to be impure.

The second guinea pig had large swellings in the groin, and was unable to use its hind limbs for a time, but it finally recovered. The rabbits and dog were not affected. At the autopsy of the horse, from which these had been inoculated, the left nasal passage and adjacent sinuses had the mucous membrane partly thickened and eroded. There were also nodules in the lung tissue.

VI. July 27, three guinea pigs were inoculated subcutaneously as before with nasal discharge from a horse affected with glanders. One of these, a small male, died August 11. On the right side of abdomen an ulcer about three-eighths of an inch in diameter, with a cup-shaped, dark, dry crust covering it. When removed, a soft, cheesy mass, involving subjacent muscles, is exposed to view; serous surface not involved. No enlargement of gland. Putrefaction had set in and no cultures were therefore made.

At this time a peculiar disease was carrying off healthy guinea pigs quite rapidly, which was traced to the dry food given them. It is probable that this guinea pig also died of this disease, although evidently infected with glanders. The second guinea pig died during my absence and no examination was made. The third, however, developed glanders in a marked degree and was killed August 23, twenty-seven days after inoculation. On the right side of abdomen, near median line, an indurated mass covered by a black crust. The abdominal muscles and the peritoneal covering are intact, but between them and the crust is a cheesy mass. Similar ulcers exist on right flank and on right thigh externally. The right fore limb and both hind limbs are swollen, especially the right hind limb. This is three-quarters of an inch thick, bluish, ulcerated between first and second toe. Internal organs seem unchanged, although the spleen contained glanders bacilli. On each of three potato cultures from this organ from 15 to 25 typical colonies appeared within three days.

VII. September 21, two guinea pigs were inoculated with nasal mucus from a horse suspected to be affected with glanders. One died October 12. There were two ulcers on the abdomen about one-half inch across, the floor of which was formed by the muscular wall of the abdomen. The inguinal gland of the same side as large as a walnut and containing a cream-colored, liquid pus. Spleen, not enlarged, contains a large number of minute whitish dots.

In all cultures on potato, from both spleen and pus of inguinal gland, the typical pale yellowish colonies of glanders subsequently appeared. The second guinea pig was killed with chloroform October 16. At the place of inoculation a small ulcer had formed and the nearest inguinal lymph gland was equal in size to a small marble. The left testicle was enlarged and contained a pus cavity. The spleen small. From the pus of the testicle an *agar* culture was prepared; a potato culture from the spleen. Only the former developed colonies of glanders bacilli.

VIII. September 22, two guinea pigs, inoculated with nasal mucus from a horse probably affected with glanders. One died September 31, very much emaciated. Over lowest ribs on the left side a cheesy nodule, about one-half inch in diameter, representing the place of inoculation. The inguinal gland of same side as large as a small bean. On the same side the subcutaneous tissue is infiltrated with a translucent exudate, sufficient to make the surface of the muscles and under surface of the skin glistening and slippery (malignant œdema?). In spleen about 15 tubercles, grayish, 1 millimeter (one-twenty-fifth inch) across; on the various lobes of the liver similar but smaller tubercles; on lungs grayish subpleural nodules, irregular in outline, embedded in areas of a dark red hepatization.

Two potato cultures were made from spleen tissue and within three days twenty to thirty drop-like colonies, resembling a pale-yellow serum, so characteristic of glanders bacilli, made their appearance.

The second guinea pig was chloroformed October 15. In the left groin the lymph gland is converted into an abscess, about the size of a marble, containing a soft, cheesy, cream-colored pus. The right testicle, enlarged, contains an abscess; a few nodules in spleen. A potato culture from the latter organ failed to develop.

IX. November 29, from a horse killed and found glandered, a guinea pig was inoculated by inserting some purulent matter from the ulcerated septum under the skin. It died December 13. At the place of inoculation just behind the right fore limb an ulcer covered with a thin scab. Underneath, a thin grayish layer of pus. Near this ulcer is a nodule equal in size to a small bean containing soft curdy pus. The inguinal gland of the same side is equally large, one-half of it converted into pus. Spleen pale, slightly enlarged, and dotted with a large number of grayish points. Testicles in abdomen not yet affected, but the fold of skin surrounding anus on the left thickened and superficially ulcerated. On section a number of yellowish modules in the thickened fold. One retro-peritoneal gland as large as a marble and converted into pus. Convex surface of both lungs dotted with a small number of bright-red points.

From the spleen and from the abscess under the skin three potato cultures and one *agar* culture were made. All developed numerous characteristic colonies of glanders bacilli on the third day.

An inspection of the autopsy notes will show that nearly all inoculated guinea pigs showed unmistakable signs of the disease, and that

only a few recovered. Of those that were killed the lesions were such as to preclude recovery. In most cases the diagnosis of glanders could be made without having recourse to cultivation. In order to be thus successful it is necessary to observe strictly the method given for inoculation, and to avoid the error of using too small a quantity of the nasal discharge. It will also be noted that the lesions characteristic of glanders in guinea pigs did not all appear in the same animal. In some, enlargement and suppuration of the inguinal glands was the only external sign; in others swelling and suppuration of the testicles took place. Again, abscesses becoming ulcers later on appeared in different parts of the body, combined with swelling of the limbs. When the external lesions were prominent internal lesions were generally less marked. The formation of nodules in the spleen was infrequent, in the lungs rare, and in the liver observed in but one case. In general, internal changes were secondary to external.

Cultivation of glanders bacilli from inoculated guinea pigs is always desirable though not absolutely necessary in many cases. The foregoing notes show that pure cultures may always be obtained from still unopened abscesses under the skin, such as those of glands and testicles, by following the method already mentioned, *i. e.*, thoroughly scorching the surface of the skin after removing the hair and then making the incision through the scorched area. This makes unnecessary the use of disinfectants. Cultures from the spleen are not always successful, when those from the abscesses are, perhaps because the bacilli are not always present in the internal organs in numbers large enough to inoculate a culture tube. Hence, it is always advisable to inoculate from any abscess that can be reached from the skin or any suppurating gland in the abdomen.

Cultures from the spleen were made by tearing off a bit of spleen pulp from the carefully exposed spleen and rubbing it gently with the platinum wire over the *agar* or potato surface, so as to free the bacilli from the tissue and distribute them over a larger surface. In this way very fine cultures of isolated colonies on potato can be obtained, which in the earliest stages, when the colonies just begin to be visible to the naked eye after a sojourn in the thermostat at 37° C. for forty-eight to seventy-two hours, are very characteristic. The *agar* cultures I have found less characteristic and hence less valuable for purposes of diagnosis. Cultures from the pus of abscesses contain a much larger number of colonies, and these are apt to be confluent unless a very small quantity is used. It is best to make several inoculations with different quantities of pus.

The potatoes used were prepared according to the method suggested by Bolton (*Medical News*, 1887-i, 318). They are pared and cut in such a way as to fit into large test tubes. The top is cut so as to form an inclined surface upon which the inoculated material is to be deposited. A small amount of water is put into the test tube to keep the lower end of the potato constantly wet. The tubes are then plugged with cotton wool and kept in the steam sterilizer from one and one-half to two hours. If then the lower end of the plug is dipped into sterile melted paraffine the evaporation and consequent drying up of the potato is reduced to a minimum. In such tubes glanders bacilli grow very well, and as a rule their growth will depend on the condition of the potato surface as regards moisture. There will be no growth, or at best a very feeble growth, if the surface of the potato is partly dry and hard.

Of the few house mice, rabbits, and the dog inoculated none took the disease, thus confirming the results of Löffler and others that these animals are not proper subjects for inoculation.

It is, in general, best to chloroform guinea pigs when the lesions have become pronounced, especially when the cultures are desired. If allowed to die the term of the disease is unnecessarily prolonged; they are very apt to die at night, and in midsummer decomposition immediately sets in. Moreover, death may take place through secondary infection of the body with septic bacteria, which enter through the ulcers. In such cases pure cultures can no longer be expected. It is often necessary to make a diagnosis as speedily as possible, to release or destroy the suspected horses as the case may be. Hence, as soon as the external lesions, such as suppuration of the glands or testicles, has fairly begun, the animal may be killed and cultivations made from the pus in these organs. This may be all the more desirable if several guinea pigs have been inoculated at the same time, one or more of which should be kept for future examination if the first should fail to yield any positive result.

Diagnosis of glanders by extirpating the submaxillary lymphatic glands and making cultures therefrom.—It has been suggested that the diagnosis of glanders in the horse may be made directly by removing during life the swollen submaxillary glands situated on the under surface of the lower jaw and making cultures from them. Such operations can of course be undertaken only by veterinarians. Occasionally the swelling of these glands is the first suspicious sign. The swelling may be simply due to an increase and condensation of the substance of the gland. When the disease has existed for weeks and months the interior of the lobes of the gland usually contain minute cavities filled with a dry, caseous substance. These are considered almost diagnostic by Dieckerhoff.

Rieck (*Zeitschr. f. Thiermedicin*, 1888, xiv, 107), recently reported a case in which the diagnosis was made in this way:

A seven-year old mare from a stable in which 6 cases of glanders had occurred within the past 6 months was suspected of glanders. The only sign upon which this suspicion was based was a painless, diffused, by no means characteristic swelling of the right submaxillary gland. There was no nasal discharge, no cough. The gland was removed, placed for 15 minutes in a $\frac{1}{10}$ per cent. solution of mercuric chloride, washed in alcohol and cut with flamed knives. In the substance of the gland were found two grayish-white soft foci as large as peas, not yet broken down. Cultures made by placing particles of these foci upon *agar* in tubes revealed the presence of glanders bacilli. The horse was killed, and at the autopsy ulcers were found on the septum, and the lungs were affected in a manner characteristic of the disease. The author rightly claims that without the aid of bacteriology the disease could not have been determined during life.

In the course of our inoculation experiments on guinea pigs, three submaxillary glands were examined and cultivations made:

In the first case the gland was as large as two hen's eggs. The gland substance was pale red. Cultures were made on *agar*, blood serum, and potato by cutting out small bits of the interior of the various lobes and rubbing these upon the culture medium, the surface of the gland being disinfected by scorching it. After the cultures had been made the gland was more thoroughly examined and a considerable number of yellowish-white spots as large as a pin's head were found, representing plugs of pus lodged in cavities. It is highly probable that some of these were transferred to the culture tubes in the pieces cut out. The tubes remained sterile, however, excepting one containing micrococci.

A second gland taken from a horse killed and found glandered was considerably swollen, the individual lobes as large as walnuts. The gland was placed in 5 per cent. carbolic acid for five minutes, then in $\frac{1}{10}$ per cent. mercuric chloride for one-half minute; finally sterile water was poured over it to remove the chloride.

The lobes were cut open with flamed knives and several cavities one-twelfth to one-eighth inch (2 to 3 millimeters) in diameter were found containing white, consistent cheesy masses. Potato and *agar* tubes inoculated with these masses remained sterile.

A third gland, which had been removed from a glandered colt at the autopsy, was examined and cultures made in the same way. The gland contained no caseous masses, and hence bits of tissue were cut out and placed on *agar* and potato tubes. Of five cultures all remained sterile but one. This contained a single colony not resembling the colonies of glanders bacilli and made up of actively motile bacilli.

So far as these experiments go, they can not be said to favor the method of diagnosis by extirpation of the submaxillary glands unless the result is only considered decisive when the bacilli of glanders have been actually found. They certainly can have little value when the result is negative.

UNITED STATES CATTLE QUARANTINE.

The superintendents of the various neat-cattle quarantine stations report the names of the importers and the number and breed of each lot of animals imported during the year 1888, as follows:

GARFIELD STATION, N. J. (NEAR NEW YORK).

DR. W. HERBERT LOWE, SUPERINTENDENT.

Date of arrival.	Name and post-office address of importer.	Port of shipment.	Name of breed.	No. of animals.
Feb. 24	Gilfillan & Murray, Maquoketa, Iowa	London	Red Polled	17
24	William Hanke, Iowa City, Iowa	do	do	22
May 2	Mack Martin, Richland City, Wis	do	do	27
2	Smith & Jamison, Mount Sterling, Ky	do	do	22
2	L. F. Ross, Iowa City, Iowa	do	do	20
4	S. A. Converse, Cresco, Iowa	do	do	15
June 26	V. T. Hills, Delaware, Ohio	Liverpool	do	13
July 11	Hon. D. Magone, New York City	London	Ayrshire	3
Aug. 24	M. W. Dunham, Wayne, Ill	Havre	French	2
Sept. 26	C. W. Chapin, Springfield, Mass	do	do	2
Oct. 11	R. W. Brown, Merton, Wis	London	Red Polled	8
25	Adams Express Company, New York City.	Bristol, England	Short Horn	2
Nov. 3	T. C. Eastman, New York City	Glasgow, Scotland	Ayrshire	10

LITTLETON STATION, MASS. (NEAR BOSTON).

DR. A. H. ROSE, SUPERINTENDENT.

Mar. 6	John A. Frye, Marlborough, Mass	London	Holstein	26
May 22	N. P. Clarke, Minneapolis, Minn	Liverpool	Short Horn	24
Oct. 1	H. S. Russell, Milton, Mass	London	Jersey	31
Nov. 10	Hopewell Brothers, Boston, Mass	do	Guernsey	15

PATAPSCO STATION, MD. (NEAR BALTIMORE).

DR. F. L. KILBORNE, VETERINARY EXAMINER.

Sept. 18	Hon. J. Stewart, Elburn, Ill	Glasgow, Scotland	Polled Angus	10

MOUNT AIRY STATION, PA. (NEAR PHILADELPHIA).

DR. A. C. YOUNG, SUPERINTENDENT.

Oct. 30	Charles W. Henry, Philadelphia, Pa	Antwerp	Swiss	11
10	Louis Bergdoll, Philadelphia, Pa	do	Holstein	6

A new station was established at Philadelpia, Pa., in October last. No contagious disease appeared among the cattle at any of the stations during the year.

REPORT OF CHEMICAL DIVISION.

FEBRUARY 1, 1889.

SIR: I have the honor to submit herewith a statement of the work done in the Chemical Division during the past year.

Respectfully,

H. W. WILEY,
Chemist.

Hon. NORMAN J. COLMAN,
Commissioner of Agriculture.

ORGANIZATION AND EQUIPMENT OF THE DIVISION.

The necessity for a new building for laboratory purposes, as set forth in my last annual report, still continues. There are many chemical operations needful in agricultural investigations which can not be undertaken at all with our present facilities, or only imperfectly. Light and ventilation in the working rooms are bad and the location of the laboratory in the basement continues to be a source of grave discomfort to the other employés of the Department.

During the year the Division met with a sad loss in the death of Mr. N. J. Fake, on the 11th of August, by accidental drowning. On certification from the Civil Service Commission Mr. E. A. von Schweinitz has been appointed to the vacancy. The staff of the Division now comprises the following names:

H. W. Wiley, chemist.
C. A. Crampton, assistant chemist.
G. L. Spencer, assistant chemist.
E. A. Knorr, assistant in laboratory.
T. C. Trescot, assistant in laboratory.
Hubert Edson, assistant in laboratory.
E. A. von Schweinitz, assistant in laboratory.
John Dugan, assistant in laboratory.
K. P. McElroy, assistant in laboratory.
Oma Carr, assistant in laboratory.
J. L. Fuelling, assistant in sugar work.
M. S. Tidd, stenographer.
Martin Johnson, laborer.

MISCELLANEOUS ANALYSES.

SAMPLES OF MINERALS, ORES, ROCKS, ETC., SUBMITTED FOR ANALYSIS.

From the Hon. J. H. Blount, House of Representatives. Sample of metal, found to be pure tin.

From J. A. C. Blackburn, War Eagle Mills, Ark. A sample of limestone, with fragments of quartz and particles of iron pyrites. No value.

Sent by G. I. Baldwin, Hunlock Creek, Pa. A specimen of sandstone with particles of mica. This might prove to be a valuable building stone if found in quantity.

From the Hon. P. B. Plumb, U. S. Senate. A sample of ore which assayed 8.5 ounces of silver per ton.

From John F. Miller, Hagerstown, Md. A specimen consisting chiefly of carbonate of lime.

From the Hon. S. W. Peel, House of Representatives. A sample of red hematite, a valuable iron ore.

From J. T. Kale, Newcastle, Va. A specimen of calcite.

From Miss Ida Hays, Redington, Nebr. A sample of mica.

From the Hon. J. H. O'Neall, House of Representatives. A sample of mineral, largely carbonate of lime.

From the Hon. Charles T. O'Ferrall, House of Representatives. Six samples of minerals, as follows: No. 1, chiefly silicates; No. 2, galena, a valuable lead ore when occurring in quantity; No. 3, iron ore; No. 4, asbestos; this might prove valuable if found in sufficient quantity; No. 5, specimen of clay, of no special value; No. 6, micaceous rock, of no special value.

Sent by the Hon. F. M. Cockrell, U. S. Senate. A sample of ore, largely galena, a valuable source of lead.

Sent by the Hon. P. B. Plumb, U. S. Senate. Seven samples of magnetite which were analyzed with the following results:

No. of sample.	Oxide of iron.	Representing metallic iron.	Silica.	Phosphorus.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
1	69.63	50.42	18.04	....
2	88.71	64.24	12.38	....
3	62.42	45.20	25.27	....
4	81.89	59.30	13.31	Trace.
5	87.64	63.46	12.50	.28
6	60.24	45.62	33.50	Trace.
7	80.91	62.21	8.10	.14

Sent by the Hon. P. B. Plumb, U. S. Senate. A sample of coal which gave the following analytical data:

Moisture	.52
Volatile combustible matter	3.16
Fixed carbon	56.54
Ash	25.73
Sulphur	14.20
	100.15

This coal is not suitable for metallurgical purposes on account of the large quantity of ash and sulphur.

Sent by Miss Lottie Randaugh, Bloserville, Pa. A sample of oxide of iron.

From the Hon. J. M. Berry, U. S. Senate. Two samples of carbonate of lime, valuable if found in quantity. Also an iron ore containing 27.67 per cent. of iron.

Sent by the Hon. J. R. Brown, House of Representatives. A sample of iron ore containing 25.62 per cent. of iron. This sample and the above are hardly rich enough to make them available for the manufacture of iron.

From the Hon. S. W. Peel, House of Representatives. A sample of mineral of no value.

From J. E. Wiley, Macon, Ga. Two samples of mineral consisting chiefly of the silicates of iron and alumina.

From Israel Shafer, Richlandtown, Pa. A sample of slate rock with particles of pyrites. No value.

From R. A. Ormdorff, Van Buren Furnace, Va. A sample supposed to be coal, proved to be slate rock of no value.

From Mrs. E. F. Whitney, Munroe, Tenn. A sample of iron pyrites.

From W. P. Newman, Coffman, Mo. A specimen of red hematite.

From Ed. Riddill, Coxburgh, Miss. A sample of iron pyrites.

From W. F. White, Dunedin, Fla. Sample of quartz with mica.

From Leak and Selph, Orange Heights, Fla. A specimen of kaolin of good quality.

From John Street, Calamine, Ark. A sample of hematite, with much silica and a trace of phosphorus; no special value.

A sample of galena which might be valuable if occurring in quantity.

From J. M. Mohr, Passer P. O., Pa. A specimen of pectolite, essentially a silicate of lime and soda, of no commercial value.

From W. P. Newman, Coffman, Mo. A specimen of gneiss with a little iron ore; a specimen of crystallized carbonate of lime, neither of which possesses any commercial value.

From Chas. S. Sterner, Coopersburgh, Pa. A specimen of silicate of the following composition:

	Per cent.
Silica	56.69
Water	18.68
Alumina	17.97
Lime	5.80
Undetermined	.86
	100.00

It has no particular value.

From F. K. DeWitt, Graysville, Va. A sample of hematite.

From E. J. Joyner, Flag Pond, Va. A good specimen of limestone.

From Chas. Brodtman, Cape Girardeau, Mo. A sample of gypsum which on analysis gave the following data:

	Per cent.
Sulphate of lime	86.94
Carbonate of lime	6.16
Iron, alumina, etc	1.84
Moisture	5.06

SAMPLES OF FERTILIZERS, FERTILIZING MATERIALS, MARLS, ETC.

Sent by James Walker, Darien, Ga. A sample of mineral containing 8.81 per cent. of phosphoric acid; enough to make it of some value for manufacturing a fertilizer.

Sent by B. Rosenfeld, Mimbres, N. Mex. A sample of mineral which was tested for phosphoric acid, a trace of which was found; not enough, however, to make it available as a fertilizer.

Sent by E. W. Stump, Tombstone, Ariz. A sample of soil containing 4.74 per cent. of organic matter.

From J. H. Williams, Accokeek, Md. Two samples of marl, one of which contained a trace of phosphoric acid. Neither sample of any value.

From W. L. Gilbert, Ocean Springs, Miss. A sample containing a large quantity of lime.

From Julius Becker, Springerville, Ariz. Sample of gypsum.

From Mrs. Seton Lyles, Collington, Md. A sample of phosphate rock; of no value as a fertilizer.

From G. A. Bacon, U. S. Department of Agriculture. A sample of rock supposed to contain phosphoric acid, none of which was detected.

From H. S. Addison, New Orleans, La. A sample of rice-chaff ash containing of phosphoric acid .71 per cent., of little value as a fertilizer.

From W. Lee White, Pension Office. A sample of marl containing phosphoric acid, .11 per cent.; nitrogen, .05 per cent. Of no value as a fertilizer.

From H. C. Perkins, Llewellyn, Oregon. A sample of stone submitted for valuation as a fertilizer; no phosphoric acid was found.

From E. T. Peters, U. S. Department of Agriculture. A sample of clay containing too much sand to make it useful for a potter's clay.

From Barthelson and Fellanders, Sanford, Fla. A very poor sample of fertilizer, containing only 1 per cent. of phosphoric acid and .51 per cent. of potash.

From O. H. Kelley, Carrabelle, Fla. A sample of marl containing .12 per cent. of phosphoric acid.

From H. C. Perkins, Llewellyn, Oregon. A sample of marl containing only a trace of phosphoric acid, of no value as a fertilizer.

From Edward Ward, Pineville, Wis. A sample of marl containing .6 per cent. of phosphoric acid.

From the Rev. Carlisle P. B. Martin, Waverly, Tex. A sample of clay highly colored by oxide of iron.

From H. G. Hanna, Pembroke, Ky. A sample of limestone of fine texture. If

available in quantity it might make a good building material or be valuable for the manufacture of lime.

From G. H. Klippinger, Cherryville, Pa. A sample supposed to be a fertilizer, containing:

	Per cent.
Ammonia	.39
Potash	.06
Phosphoric acid	1.56

Almost worthless as a fertilizer.

From G. A. Grover, Horace, Dak. Analysis of sample of clay:

	Per cent.
Alumina	33.39
Iron FeO	5.49
Lime	3.96
Silica	48.97
Phosphoric acid	.05
Alkalis	Trace.
Organic matter	15.44
Moisture	5.97

From H. M. Smith, Lenah, Va. A sample of rock of no value.

From Joseph H. Key, Leonardstown, Md. A sample of green sand containing .47 per cent. of phosphoric, a trace of iron, and no potash. Of little value as a fertilizer.

From the Hon. J. M. Allen, H. R. A sample supposed to be suitable for the manufacture of cement. It was a mixture of limestone and sandstone, not exhibiting the proper hardening qualities.

From James M. Michael, Barnhart's Mills, Pa. A sample supposed to be a marl; was found to be a clay of no fertilizing properties whatever.

SAMPLES OF SORGHUM CANES, SUGAR BEETS, AND SIRUPS.

Sent by C. W. Wood, Hertford, N. C., two samples of sorghum cane:

	Amber.	Orange.
	Per cent.	*Per cent.*
Total solids	14.10	13.70
Sucrose	6.40	6.19
Glucose	4.97	(*)

* Not determined.

This cane does not appear to be quite ripe; would make a good sirup, but is unfit for sugar-making purposes.

Sent by David Cox, Hertford, N. C., two samples of sorghum cane:

	Early Orange.	Late Orange.
Juice .... per cent..	56.17	54.57
Sucrose .... do....	7.67	8.69
Glucose .... do....	3.87	4.58
Specific gravity	1.050	1.061
Degrees Brix	13.00	14.70
Temperature .... deg. C..	22.5	22.7

Also a sample of Early Amber:

	Per cent.
Total solids	15.70
Sucrose	8.14
Glucose	6.62

Not suitable for sugar making purposes but would probably give a large yield of sirup.

Sent by W. B. Shaw, Shawborough, N. C., two samples of sorghum cane:

	No. 1.	No. 2.
Juice..........per cent..	....	58.88
Sucrose ....do....	11.05	7.07
Glucose ....do....	3.83	3.87
Specific gravity	....	1.05
Degrees Brix	16.4	12.20
Temperature....deg. C..	....	24.00

No. 1 is a rich cane for sugar-making purposes.
Sent by John Upton, Belcross, N. C., two samples of sorghum cane:

	Early Amber.	Early Orange.
Juice..........per cent..	56.80	55.20
Sucrose ....do....	12.28	7.94
Glucose ....do....	2.57	4.80
Specific gravity...........	1.06	1.05
Degrees Brix	16.10	13.00
Temperature....deg. C..	24.6	25.00

Sent by Harvey Terry, Terry's Manor, North Carolina, four samples of sorghum cane:

	Early Amber.	Late Orange.	Amber.
Juice..........per cent..	54.44	55.95	54.58
Sucrose ....do....	6.05	7.42	7.09
Glucose ....do....	5.23	4.00	4.37
Specific gravity	1.05	1.05	1.05
Degrees Brix	12.00	12.22	12.00
Temperature....deg. C..	24.70	23.00	23.00

No. 4 had undergone acid fermentation and analyzed as follows:

	Per cent.
Total solids..	16.30
Sucrose	7.57
Glucose	4.75

Sent by Densmore Bros., Red Wing, Minn., a sample of sorghum molasses:

	Per cent.
By direct polarization........................sucrose..	46.30
By invert polarization ....do....	49.16
Reducing sugars..	30.40

It is rich in sucrose and ought to yield a large crop of crystals if boiled to the proper density.
Sent by A. F. George, Ada, Minn., two samples of sugar beets:

	White beets.	Yellow beets.
Juice ....per cent..	59.66	69.47
Moisture ....do.....	89.99	89.45
Purity....................	60.27	59.44
Sucrose.......per cent..	6.69	5.41
Specific gravity	1.043	1.035
Degrees Brix............	11.10	9.10
Temperature .....Cent..	20°	22°

These are both below the average for sugar beets in this country.

Sent by C. W. Scarff, Grand Island, Nebr, two samples of sugar beets:

	Vilmorin.	White Imperial.
Total solids . per cent.	18.40	18.80
Sugar ....do....	15.38	15.75
Purity	83.59	83.77

These are very rich and capable of producing not less than 230 pounds of sugar per ton of beets.

Sent by William Juntgen, Kansas, Ill., a sample of sugar beet:

Total solids..............................per cent..	10.40
Sucrose ....do.....	4.73
Purity..	45.48

These beets are unfit for the manufacture of sugar.

Sent by W. C. Buderus, Sturgis, Dak., two samples of sugar beets:

	Pink beets.	White beets.
Total solids... per cent..	20.40	21.48
Sugar ....do.....	13.32	15.03
Purity co-efficient.......	65.29	69.97

A high percentage of sugar, but also a large quantity of total solids.

Sent by Hon. E. N. Morrill, House Representatives. Sample of sorghum molasses, too small a quantity for analysis.

Sent by H. S. Trescot, Pendleton, S. C. Two samples of sorghum sirup.

	No. 1.	No. 2.
	Per cent.	*Per cent.*
Moisture................	21.48	28.60
Ash.....................	2.76	1.92
Glucose.................	35 97	38.48
Sucrose.................	39.20	33.10

Sent by the Hon. F. M. Cockrell, U. S. Senate. A sample of molasses:

	Per cent.
Sucrose	42.00
Glucose	26.29
Moisture	28.13
Ash	2.63
Undetermined	.95

ANALYSES OF SAMPLES OF WATER.

From E. W. Deming, Conway Springs, Kans. Two samples of water: River water, 20.07 grains total solids per United States gallon. Well water, 12.52 grains total solids per United States gallon.

These waters are both excellent for technical purposes.

From H. L. Long, Walnut, Tex. A sample of water containing 201.88 grains of solids per gallon, comprised chiefly of sulphate of calcium and some chloride of sodium.

From Henry Peaslee, Georgetown, Tex. A sample of water containing 655.55 grains of solids per United States gallon. A partial quantitative analysis of the solid matter showed the following composition:

Sodic chloride.......grains per United States gallon..	194.77
Magnesia..................................do......	26.88
Alumina...................................do.... .	57.77

This water is unfit for drinking purposes.

Sent by H. B. Bicksler, Herndon, Va. A sample of water containing 19 grains of total solids per gallon, consisting of carbonates and sulphates of lime and magnesia, with organic matter, and traces of alkaline chlorides.

From W. H. Thomas, La Grange, Mo., a sample of water a complete analysis of which was made:

	Grains per United States gallon.
Sulphate of sodium	9.223
Chloride of sodium	320.607
Carbonate of potassium	6.174
Carbonate of sodium	.748
Carbonate of calcium	35.836
Carbonate of magnesium	20.532
Alumina	.093
Ferric oxide	Trace.
Silica	2.891
Total solids	396.104

From the Hon. J. N. Burnes, House of Representatives, a water containing 38.59 grains of solids per gallon, consisting of lime, magnesia, alumina, iron, and alkalis combined with sulphuric, carbonic, and hydrochloric acids and silica.

Sent by the Hon. C. T. O'Ferrall, House of Representatives, a sample of water containing 15.87 grains per gallon of solids, consisting of the same ingredients as the above sample.

From J. P. Eaton, Mapleville, Nebr., two samples of water. Water from 25-foot well contains 38.43 grains of solids per gallon; water from 91-foot well contains 20.07 grains of solids per gallon.

The composition of the solid matter is the same as in the two preceding samples.

From the Hon. Samuel Pasco, U. S. Senate, a sample of water, a complete analysis of which was made:

		Parts per million.
Oxygen required by organic matter		31.50
Free ammonia		.44
Albuminoid ammonia		.18
Nitrates		
Nitrites		Trace.
Total solids	grains per gallon	167.50
Chlorine	do	62.68

The solid matter consists of—

Lime	grains per gallon	9.96
Magnesia	do	3.01
Sodic chloride	do	61.66
Soda	do	5.88
Potassic chloride		Trace.
Sulphuric acid	grains per gallon	9.27
Carbonic acid	do	7.86
Silica	do	.60
Iron and alumina		Trace.
Undetermined	grains per gallon	1.74
		100.00

This is a mineral water and might prove to possess medicinal virtues.

MISCELLANEOUS SAMPLES.

From M. J. Albright, Rago, Kans. A sample of salt containing 98.86 per cent. of sodic chloride.

From Mrs. Jenkins, Washington, D. C. A sample of powders which was tested for bromides, chloral, and morphine, with negative results.

From Mrs. Grigsby, Washington, D. C. A sample of milk containing:

	Per cent.
Total solids	9.76
Fat	1.65
Albuminoids	3.09

This is a very inferior sample of milk, having been deprived of at least two-thirds of its cream.

From E. S. Stover, Albuquerque, N. Mex. A sample of cane, for valuation as a fodder:

	Per cent.
Albuminoids	3.68
Fat and oil	3.58
Alcohol extract	26.34
Crude fiber	13.35

It is deficient in nitrogenous principles, but might prove an acceptable change of diet for cattle.

Sent by D. J. Fair, Sterling, Kans. A sample of brine:

Specific gravity	1.1892
Total solids	25.09

In the dry substance there was found:

	Per cent.
Sodic cloride	91.95
Magnesia	1.86
Sulphuric acid	.89
Undetermined	5.30

Sent by R. F. Bond, Sterling, Kans., two samples of brine and two samples of salt:

	Brine 1.	Brine 2.	Salt 1.	Salt 2.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
Total solid matter	27.51	27.07	90.33	94.98
Sodic chloride	26.18	24.65	86.63	90.45
Magnesia	.07	.49	.11	.08
Lime	Trace.	Trace.	.44	1.25
Sulphuric acid	.23	.42	.51	.78
Moisture	72.85	72.93	9.67	5.02
Undetermined	.67	2.51	4.64	2.45

Submitted by Professor Alwood, Department of Agriculture. An insect powder in which arsenic in quantity was found.

From the Hon. E. O. Graves, Superintendent of Bureau of Printing and Engraving. A sample of linseed-oil:

Specific gravity at 15.5° C	.9325
Percentage of iodine observed	152.00
Refractive index at 17.5° C	1.4785

No adulteration was discovered.

Sent by Nelson Page, Washington, D. C., a sample of rye flour supposed to have been sifted:

	Per cent.
Crude fiber	11.44
Starch	24.05

The sample resembles rye bran rather than flour, and has evidently been sifted.

From Dr. F. L. Kilbourne, U. S. Department of Agriculture. Two samples of linseed-oil cake:

	No. 1.	No. 2.
	Per cent.	*Per cent.*
Starch	20.78	19.18
Crude fiber	4.23	5.96
Moisture	8.38	7.84
Ash	5.79	5.72
Fat and oil	9.05	4.28
Alcohol extract	12.80	12.91
Albuminoids	31.69	38.69

From C. F. Hopkins, United States Department of Agriculture. Two samples of grapes.

	No. 1.	No. 2.
	Per cent.	*Per cent.*
Sucrose	6.99	3.75
Reducing sugars	9.53	10.54
Total sugars	16.52	14.29

From Prof. Cummings Cherry, Chicago, Ill. Specimen of palmetto root, stalk, and leaves.

	Root.	Stalk.	Leaves.
	Per cent.	*Per cent.*	*Per cent.*
Ether extract	.71	.49	2.79
Albuminoids	1.66	2.10	7.79
Crude fiber	45.85	46.30	50.22

SAMPLES ANALYZED FOR THE ASSOCIATION OF OFFICIAL AGRICULTURAL CHEMISTS.

Samples received from Prof. J. A. Meyers, chairman of committee on potash.

	By method of A. O. A. C.		By Lindo Gladding method.
No. 1. Potassic chloride	*Per cent.* KCl. 85.04	*Per cent.* KCl. 84.83*	*Per cent.* KCl. 85.64
	85.16	84.71*	85.56
	85.06	84.08*	
No. 2. C. P. potassic sulphate	....	*Per cent.* K_2O. 55.48	*Per cent.* K_2O. 54.10
		53.68	54.02
		....	53.86
No. 3. Acid phosphate with potassic sulphate	....	13.70	13.62
		13.82	13.72
		13.89	13.78
No. 4. Calcined kainite	....	17.20	17.32
		17.20	17.26
		17.26	....
No. 5	....	4.96	5.13
		4.99	5.30

Analyses made by A. E. Knorr, except those marked *, which were made by Dr. C. A. Crampton.

Samples from Dr. W. J. Gascoyne, chairman of committee on phosphoric acid. Analyzed by A. E. Knorr:

	Moisture.	Phosphoric acid.
	Per cent.	*Per cent.*
No. 1. South Carolina phosphate	.76	28.16
No. 2. Tankage	6.44	14.23

	No. 3. Ammoniated superphosphate.	No. 4. Dissolved South Carolina phosphate.	No. 5. Dissolved Navassa phosphate.
	Per cent.	*Per cent.*	*Per cent.*
Moisture	14.06	9.33	8.25
Soluble phosphoric acid	6.74	10.63	6.78
Reverted phosphoric acid	1.59	3.31	7.94
Available phosphoric acid	8.33	13.94	14.72
Insoluble phosphoric acid	1.30	1.28	3.34
Total phosphoric acid	9.63	15.22	18.06

Samples from Prof. M. A. Scovell, chairman of committee on nitrogen. Analyses made by T. C. Trescot: No. 1, potassium nitrate C. P.; No. 2, cotton-seed meal; No. 3, sodium nitrate C. P., ammonium sulphate C. P., cotton-seed meal and acid phosphate; No. 4, sodium nitrate C. P., cotton-seed meal, muriate of potash and acid phosphate; No. 5, a mixed tankage of the trade.

	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.
	Per ct. N.	*Per ct. N.*	*Per ct. N.*	*Per ct. N.*	*Per ct. N.*
By soda-lime method	....	7.14	....	....	2.85
By Kjeldahl method	....	7.50	....	....	2.91
By Kjeldahl modified for nitrates	13.73	....	3.70	3.13	....
By Ruffle method	13.83	7.47	3.86	3.16	2.97

Sample received from Prof. Richard H. Gaines, chairman of committee on phosphoric acid. Analyzed by E. A. von Schweinitz and J. L. Fuelling:

	Schweinitz.			Fuelling.		
	No. 1.	No. 2.	No. 3.	No. 1.	No. 2.	No. 3.
Soluble phosphoric acid	....	10.72	6.63	....	10.72	6.74
Reverted phosphoric acid	....	2.13	1.90	....	1.92	1.80
Available phosphoric acid	....	12.85	8.53	....	12.64	8.54
Insoluble phosphoric acid	....	1.53	1.62 / 2.01	....	1.93	2.00
Total phosphoric acid	21.81	14.38	10.15	22.03	14.57	10.53

In connection with the investigation on the nature and causes of "peach yellows" carried on by the Division of Pathological Botany of this Department, a series of ash analyses of the different parts of the peach tree was made by A. E. Knorr. A full discussion of these analyses will be found in the special bulletin published by that division on this subject.

SWEET CASSAVA.*

(*Jatropha manihot* or Aïpi.)

About the middle of March, this year, I received from Mr. R. H. Burr, of Bartow, Fla., a package of cassava roots. These roots reached the Department in fine condition, being apparently as fresh as the day they were taken from the soil. After careful sampling and cleaning, a sufficient quantity of the roots was cut into thin slices and thoroughly dried. In a definite weighed portion, sampled as carefully as possible, the percentage of moisture was determined. The dried and powdered roots were preserved for future analysis. Owing to a press of other matter, this analysis was not made until the latter part of July and the first of August this year. Mr. Burr, in forwarding the roots, sent the following information concerning them:

The roots do not last long after digging, drying up or rotting. Since this variety of cassava is not the bitter or poisonous kind, it is generally known in Florida as the sweet cassava. The roots are fed to all kinds of stock in a fresh state, and are greatly relished. It has been sufficiently tested here to show its great value as a stock food. The yield under favorable conditions is astonishing. I have recently dug one plant of one year's growth, which weighed 50 pounds, being at the rate of more than 1,500 bushels to the acre. Eight hundred to 1,000 bushels per acre can be confidently reckoned on.

*Read by permission of the Commissioner of Agriculture at the Cleveland meeting of the Society for the Promotion of Agricultural Science, August, 1888, and published in Agricultural Science, vol. 2, No. 10, and Botanical Gazette, vol. 14, No. 3, p. 71.

The roots received by us were long and slender, and of various sizes; some of them were quite 2 feet long, and weighed several pounds. The bark, which contains the poisonous principle, if any be present, was carefully scraped off and has been preserved for subsequent examination. The analysis of the sample, calculated to dry substance, is given in the following table:

Serial No		5547
Ash	per cent..	1.94
Oil (petroleum ether extract)	do....	1.27
Ether extract (glucosides, alkaloids, organic acids, etc.)	do....	.74
Alcohol extract (amids, sugars, resins, etc.)	do....	17.43
Crude fiber	do....	4.03
Starch	do....	71.85
Albuminoids (calculated from nitrogen)	do....	3.47
		100.73

In regard to the method of analysis, little need be said; it was carried on in accordance with the well-established rules of plant analysis as laid down by Dragendorff. The first extraction of petroleum ether gave the fat or oil alone, and the subsequent extraction with sulphuric ether gave the glucosides, alkaloids, and organic acids. That portion of nitrogen existing as amids has been estimated in the alcoholic extract. The total nitrogen was also estimated and entered as albuminoids; a small portion of the nitrogen has thus been counted twice in the total results which add up a little over 100. A characteristic feature of the cassava root is shown in the large amount of substance present soluble in alcohol. The amount of starch also compares fairly well with the best varieties of potatoes. On account of the large quantity of sugars present, the cassava root could be more economically used for the manufacture of glucose than for starch; their is no doubt, however, of the fact that a fine article of starch food can be made from the cassava root growing in this country.

In addition to the fresh root above noted, two samples of the dried root or cassava meal have also been examined. No. 5922 was sent to us, described as pulverized manihot root or cassava flour. The root is first peeled, chopped into thin sclices, dried in the sun two days, and pulverized. It was prepared by Prof. W. H. Kern, of Bartow, Fla. No. 5923 was labeled pulverized cassava, with the starch, or a portion of it, and glucose washed out, the remaining pulp dried in the sun, prepared by Professor Kern.

Professor Kern sent a letter with the samples, from which the following extracts are made:

Allow me to say that owing to the prodigious yield per acre of what we here know as cassava, and its alleged value as a feed and food plant, and for its yield of starch and glucose, it is attracting a very great deal of attention here now. The plant here grown is different from the manioc root of South and Central America; our root contains no poisonous elements which need to be dissipated by heat. It is customary here for many persons to make their own starch from it. The root, which must remain in the ground until one is ready to use it, is dug, washed, and its two inner and outer peelings removed; it is then grated and the pulp washed, the water poured off in a vessel and allowed to stand, when the pure starch settles in the bottom. The clear water is again drawn off and the starch allowed to dry. The pulp, after having the starch washed out, may be used at once in making puddings by the addition of milk, eggs, etc. This washed pulp may be sun-dried and thus kept, forming valuable meal or flour from which nice bread may be made. Necessitated as we are in south Florida to buy all our wheat flour, anything which acts as a substitute, either in whole or in part, is of great value to us.

The analyses of two samples of flour are given in the following table:

Serial No.	5922	5923
Water ... per cent..	10.56	11.86
Ash ... do....	1.86	1.13
Oil and fat ... do....	1.50	.86
Glucosides, alkaloids, and organic acids..do....	.64	.43
Amids, sugars, resins ... do....	13.69	4.50
Dextrine, gum, etc., by difference ... do....	2.85	5.63
Crude fiber ... do....	2.96	4.15
Nitrogenous bodies ... do....	1.31	1.31
Starch ... do....	64.63	70.13

From the above analyses it is seen that the cassava can never take the place of the flour made from cereals, as a food material, on account of the small portion of nitrogenous matter which it contains. It seems to me, however, that it might very well take the place of potatoes, and its value as a food should not be underestimated.

Mr. S. W. Carson, of Midland, Fla., has made some very valuable contributions to the literature of the native cassava. From a letter of his to the *Florida Farmer and Fruit Grower* of April 11, 1888, I make the following quotations:

As before stated, I regard the rolling pine lands, containing some willow oak, to be the best for cassava, and the southern counties to be best suited to it. Let the soil be well prepared by plowing and harrowing, rows checked about 4 feet apart, one piece laid in each hill. I think they should never be closer together than 4 feet, and 5 would be better. Cassava has been known to grow for three years in this country. It will continue to grow until the cold kills it, then by breaking off the stems when they are red, the stubble will sprout up in the spring. As to the seeds of the cassava they will ripen in about one year. If puddings, custards, etc., are desired, the roots must be peeled and grated; salt, sugar, etc., may be used according to taste. The Spaniards make bread of it simply by grating the root, and adding salt and a little soda. Now there is no doubt in my mind but that thirty tons of cassava root per acre can be produced. When I think of the tapioca, glucose, and starch there are in it, and how abundantly it can be turned into bacon and lard, milk and butter, mutton and beef, I feel confident that it will pay better than any other plant in the world.

Mr. J. H. Moore, of Keuka, Fla., in a letter to the same paper of November 24, 1887, describes some of the uses of cassava. From his letter I make the following extract:

Cut the stalks about 1 inch above the ground, just before frost; after cutting, the stalks should be left to dry in a cool place a few weeks, and then placed in a trench and covered until time for planting. Some save the stalks by keeping them in a dry, cool place until February and then plant. The roots should be dug as used; they will not keep in good condition out of the ground more than three or four days. It is perhaps the best feed we can raise for hogs; it is also a fine feed for poultry. We often bake it like sweet potatoes, and also slice and fry it like Irish potatoes.

M. Sacc has addressed a letter to the National Society of Agriculture of France, concerning the cassava which he calls "*Manihot utilissima.*" He is of the opinion that the poisonous varieties are different botanically from the innocent. Manihot is the bread of tropical regions. The innocent variety is cultivated in Bolivia, and the botanists there call it "manihot aïpi." The plant grows from 1 to 2 meters in height, with straight and naked stalks, since they only develop leaves at their extremities; the only care given to them in their cultivation is to keep them free from weeds. The roots, to the number of five to nine, are of the size of the closed hand. The following analysis of the roots of the manihot aïpi is given:

	Per cent.
Water	70.29
Starch	14.40
Sugar, salts, and malic acid	1.01
Fibrin and yellow coloring matter	.08
Crude fiber	3.16
Ash	10.82

From the above it is seen that the roots of the tropical plant are quite different from those produced in our own country. In regard to the distribution of the two varieties, M. Sacc makes the following observation:

In Cuba I have seen only the poisonous variety. The same is true of Brazil, where I have not seen the manihot aïpi except in the Swiss colony, Porto Real. As to the product of the two varieties, it is the same; the stalks, which are the size of the finger, are from 1 to 2 meters in height. I have not been able to analyze the leaves of this interesting vegetable, but as they are much sought after by cattle, they are probably very nutritious.

The above quotation from M. Sacc's paper I have taken from the *Revue Agricole* (ii, 6, pp. 81, 82), published at Port Louis Maurice.

The name cassava should be applied properly only to the purified starch derived from the roots of the plant. The plant is known under the botanical names *Janipha manihot*, *Manihot utilissima*, *Jatropha manihot*, *Manihot aïpi*, and *Jatropha Laefflingii;* it is also called the mandioc plant. The fleshy root of this plant yields the greatest portion of the daily food of the natives of tropical America, and its starch is known in this country under the name of tapioca. Manihot is a woody or shrubby plant growing from fleshy tuberous roots, the stems being smooth and the leaves generally long-stalked. The leaves of the poisonous variety usually have seven branches palmately divided; the leaves of the sweet variety are usually only five parted. In the "Treasury of Botany," page 718, the following remarks are made concerning these two varieties:

It is quite clear that while the root of one is bitter and a virulent poison, that of the other is sweet and wholesome, and is commonly eaten cooked as a vegetable. Both of them, especially the bitter, are most extensively cultivated over the greater part of tropical America, and yield an abundance of wholesome and nutritious food; the poison of the bitter kind being got rid of during the process of preparation it undergoes. The poisonous expressed juice, if allowed to settle, deposits a large quantity of starch known as Brazilian arrow-root or tapioca meal, from which the tapioca of the shops is prepared by simply torrefying the moist starch upon hot plates, the heat causing the starch grains to swell and burst and become agglutinated together. A sauce called *cassareep*, used for flavoring soups and other dishes, particularly the West Indian dish known as pepper-pot, is also prepared from this juice by concentrating and rendering it harmless by boiling. Another of the products of cassava is an intoxicating beverage called *piwarrie*, but the manner of preparing it is not calculated to render it tempting to Europeans. It is made by the women who chew cassava cakes and throw the masticated materials into a wooden bowl where it is allowed to ferment for some days, and then boiled. It is said to have an agreeable taste.

From the above analyses of cassava root, descriptions of its uses, and the amount of it that can be produced per acre, it is evident that it is destined to become a valuable agricultural product of the subtropical portions of our country.

LARD AND ITS ADULTERATIONS.

Lard is a term applied to the fat of the slaughtered hog separated from the other tissues of the animal by the aid of heat.

In the crude state it is composed chiefly of the glycerides of the fatty acids, oleic and stearic or palmitic, with small portions of the connective tissues, animal gelatine and other albuminous matters.

Kinds of lard.—According to the parts of the fat used and the methods of rendering it lard is divided into several classes. According to methods of rendering lard is classed as kettle and steam. From material used the following classification may be made:

Neutral lard.—Neutral lard is composed of the fats derived from the leaf of the slaughtered animal, taken in a perfectly fresh state. The leaf is either chilled in a cold atmosphere or treated with cold water to remove the animal heat. It is then reduced to a pulp in a grinder and passed at once to the rendering kettle. The fat is rendered at a temperature of 105° to 120° Fahr. (40° to 50° C.) Only a part of the lard is separated at this temperature and the rest is sent to other rendering tanks to be made into another kind of product. The lard obtained as above is washed in a melted state with water containing a trace of sodium carbonate, sodium chloride, or a dilute acid. The lard thus formed is almost neutral, containing not to exceed .25 per cent. free acid; but it may contain a considerable quantity of water and some salt. This neutral lard is used almost exclusively for making butterine (oleomargarine).

Leaf lard.—The residue unrendered in the above process is subjected to steam heat under pressure and the fat thus obtained is called leaf lard. Formerly this was the only kind of lard recognized in the Chicago Board of Trade and was then made out of the whole leaf.

Choice kettle-rendered lard; choice lard.—The quantity of lard required for butterine does not include all of the leaf produced. The remaining portions of the leaf, together with the fat cut from the backs, is rendered in steam jacketed open kettles and produces a choice variety of lard known as "kettle rendered." The hide is removed from the back fat before rendering and both leaf and back fat are passed through a pulping machine before they enter the kettle. Choice lard is thus defined by the regulations of the Chicago Board of Trade:

"*Choice lard.*—Choice lard to be made from leaf and trimmings only, either steam or kettle rendered, the manner of rendering to be branded on each tierce."

Prime steam lard.—The prime steam lard of commerce is made as follows: The whole head of the hog, after the removal of the jowl, is used for rendering. The heads are placed in the bottom of the rendering tank. The fat is pulled off of the small intestines and also placed in the tank. Any fat that may be attached to the heart of the animal is also used. In houses where kettle-rendered lard is not made the back fat and trimmings are also used. When there is no demand for leaf lard the leaf also is put into the rendering tank with the other portions of the body mentioned. It is thus seen that prime steam lard may be taken to represent the fat of the whole animal, or only portions thereof. The quantity of fat afforded by each animal varies with the market to which the meat is to be sent. A hog trimmed for the domestic market will give an average of about 40 pounds, while from one destined for the English market only about 20 pounds of lard

will be made. Prime steam lard is thus defined by the Chicago Board of Trade:

"*Prime steam lard.*—Standard prime steam lard shall be solely the product of the trimmings and other fat parts of hogs, rendered in tanks by the direct application of steam, and without subsequent change in grain or character by the use of agitators or other machinery, except as such change may unavoidably come from transportation. It shall have proper color, flavor, and soundness for keeping, and no material which has been salted shall be included. The name and location of the renderer and the grade of the lard shall be plainly branded on each package at the time of packing."

This lard is passed solely on inspection, the inspector having no authority to supervise rendering establishments in order to secure a proper control of the kettles. It is reported on authority that the large intestines, after proper cleaning, are placed in the rendering tanks. According to the printed regulations any part of the hog containing fat could be legally used.

Since much uncertainty exists in regard to the disposition which is made of the guts of the hog I have had the subject carefully investigated. Following are the results of the study:

Guts.—Definition of the term as used by hog-packers is: Everything inside of a hog except the lungs and heart, or, in other words, the abdominal viscera complete. The material is handled as follows:

When the hog is split open the viscera are separated by cutting out the portion of flesh surrounding the anus and taking a strip containing the external urino-generative organs. The whole viscera are thrown on a table and divided as follows: The heart is thrown to one side and the fatty portion trimmed off for lard. The rest goes into the offal tank or sausage. The lungs and liver go into the offal tank or sausage. The rectum and large intestines are pulled from the intestinal fat and peritoneum and along with the adhering flesh and genito-urinary organs sent to the trimmer. All flesh and the above-mentioned organs are trimmed off and the intestine proper is used for sausage casing. The trimmings, including the genito-urinary organs, are washed and dumped into the lard tank. The small intestine is also pulled from the fatty membrane surrounding it and saved for sausage casings. The remaining material, consisting of the peritoneum, diaphragm, stomach, and adhering membranes, together with the intestinal fat, constitute the "guts," which are seen undergoing the process of washing, which is usually conducted in three or four different tanks. As the "guts" pass into the first tank the stomach and peritoneum are split open, and also any portions of the intestines which sometimes adhere to the peritoneum. After receiving a rough wash they are passed from tank to tank when, after the third or fourth wash, they are ready for the rendering tank. The omentum fat is cut from the kidneys and the kidneys, with a little adhering fat, go into the rendering tank. Spleen and pancreas go into lard tanks, as do also the trachea, vocal cords, and œsophagus.

To sum up, it is safe to say that everything goes into lard, or rather the lard tank, with the following exceptions:

(1) The intestines proper, which are saved for sausage casings.
(2) The liver and lungs.
(3) That part of the heart free from fat.

I have been told that in killing small hogs, and also when there is

small demand for sausage casings, it is frequently the practice to split the intestines so as to save expense of pulling from the fat; and after washing, fat and all go into the tank. I have no other evidence except that I have often seen lard with a distinctly "gutty flavor," which must have been caused by this or some similar mode of handling. Of course it will often happen that the intestines break off and portions adhere to the enveloping tissue, and consequently get into the tank after washing.

It is a commercial fact that sausage casings are worth more than the small amount of adhering fat, and consequently packers will save them. Small hogs produce small casings difficult to pull, and it is reasonable to believe that they will be handled in the simpler manner. They break so easily they are hardly worth saving separately. It is stated by lard manufacturers that the lard made from the parts of the intestines mentioned above is used for the manufacture of lard oil and soap, and does not enter into the lard of commerce.

Butchers' lard.—The small quantities of lard made by butchers is usually "kettle rendered," after the manner practiced by small farmers in making lard for home consumption. Often the scraps are saved up for a considerable length of time by the butchers before rendering, and this is likely to increase the free acid present. This lard is also frequently dark colored and contains a considerable quantity of glue. In New York this lard is known as "New York City lard."

Other hog-fat products.—There are many other hog-fat products not used in the manufacture of lard or compound lard a description of which, however, may prove useful here.

White grease.—This grease is made chiefly from hogs which die in transit by being smothered or frozen. Formerly it was also made from animals dead of disease, but this product has of late been diminished on account of certain State laws requiring the carcasses of hogs which have died of cholera to be buried. This grease is made from the whole animal with the exception of the intestines. The latter are rendered separately and make "brown grease." The rendering is done in closed tanks at a high pressure. The residue is used in the manufacture of fertilizer. White and brown grease are used chiefly in the manufacture of low-grade lard oils and soap.

Yellow grease.—Yellow grease is made by packers. All the refuse materials of the packing-houses go into the yellow-grease tank, together with any hogs which may die on the packers' hands. Yellow grease is intermediate in value between white and brown. It is used for the same purposes.

Pigs'-foot grease.—This grease is obtained chiefly from the glue factories, and is used for making lard oils and soap.

Stearines.—The stearines are the more solid portions of the animal fats remaining after the more fluid portions have been removed by pressure. The stearines used in the manufacture of compound lard are lard stearine, derived from lard, and oleo-stearine derived from a certain quality of beef tallow.

Lard stearine.—The lard stearine used in compound lard is made as follows:

The prime steam lard, if properly crystallized and of the right temperature (from 45° to 55° Fahr., winter, 55° to 65° summer) is sent at once to the presses. If not properly grained, it is remelted and kept in a crystallizing room at 50° to 60° Fahr. until the proper grain is

formed. The lard is then wrapped in cakes with cloth, each cake containing 10 to 20 pounds. The cakes are placed in a large press, with suitable septa to facilitate the egress of the oil. These presses are sometimes 40 to 50 feet in length, and when first filled 12 to 18 feet high. The pressure is applied very gradually at first by means of a lever working a capstan about which the chain is wrapped attached to the upper movable part of the press.

The oil expressed, prime or extra lard oil, is used for illuminating and lubricating purposes. The resulting stearine is used for making compound lard and is worth more than the lard oil. It has about .5 per cent. free fatty acid (less than the lard oil) and crystallizes in long needles, making the texture tough.

Oleo stearine.—This product is made chiefly from the caul fat of beeves. This fat is rendered in open kettles at a low temperature. The resulting tallow is placed in cars in a granulating room where it is allowed to remain for thirty-six to forty-eight hours at a temperature 80° to 90° Fahr. The contents of the cars are then mixed and placed on a revolving table where they are made into a cake. This cake is then wrapped with strong cotton cloth and placed in a strong press where a gradual pressure at 90° Fahr., becoming very strong at the end, is applied for one to two hours. The expressed oil, known as oleo oil, is used in the manufacture of butterine. The stearine is removed from the prêss as white, hard cakes and is used for adulterating lard. The oil is sometimes filtered with a small percentage of fuller's earth to improve its color and brightness.

Mutton tallow.—A fine article of mutton tallow is also sometimes used in lard, but the objection to the flavor is sufficient to limit its use to a small amount.

The following general remarks on beef fat will be found instructive:

Beef fat.—Before the day of the oleomargarine industry, all fat rendered from the tissues of cattle was known commercially as tallow. Since then differentiation has taken place, and the term tallow no longer is sufficient to designate the several products obtained from the rendered fat of the beef. We have first "butter stock," which is rendered from the caul fat at a low temperature, and from which is manufactured by means of pressure—

(1) Oleo oil.

(2) Oleo stearine (beef stearine).

The kidney fat, as a rule, is left with the carcass and constitutes what is known as suet. Marrow stock, as its name implies, is rendered marrow fat, and when properly prepared is almost equal to butter stock in quality. Tallow is made from the trimmings and portions of the viscera. Its color varies from white to yellow, according to the portions of the animal which have been used and the care with which they have been prepared for rendering, and the temperature at which rendered. When freshly and carefully rendered tallow should show less than 1.5 per cent. of free fatty acid. The tallow on the market will show anywhere from 2 to 10 per cent. Its flavor varies, never being good enough for lard.

PROPERTIES OF PURE LARD.

PHYSICAL PROPERTIES.

Specific gravity.—The specific gravity of a pure lard varies rapidly with the temperature. It is not convenient to take the specific gravity of a lard at a lower temperature than 35° or 40°, inasmuch as

below that temperature solidification is apt to begin. The specific gravity, therefore, is usually taken at 35° or 40° or at the temperature of boiling water, viz, 100°. At 40° the specific gravity of a lard varies from .900 to .904. At 100° the specific gravity is found to vary between the numbers .860 and .865. The specific gravity of pure lard is very near that of many of the substances used in adulterating it, but is distinctly lower than that of cotton oil, and is of very great distinctive value in analysis.

Melting point.—The melting point of a pure lard is a physical characteristic of great value. The melting point of the fat of the swine varies with the part of the body from which it is taken. The fat from the foot of the swine appears to have the lowest melting point, viz, 35.1°. The intestinal fat seems to have the highest, viz, 44°. In fat derived from the head of the animal the melting point is found to be 35.5°, while the kidney fat of the same animal shows a melting point of 42.5°. In steam lards, representing the lards passed by the Chicago Board of Trade, the melting point, for ten samples, was found to vary between 29.8° and 43.9°. In general it may be said that the melting point of steam lards is about 37°. In pure lards derived from other localities the melting point was also found to vary. A sample of lard from Deerfoot Farm, Southborough, Mass., was found to have a melting point of 44.9°, while a pure lard from Sperry & Barnes, New Haven, Conn., melted at 39°. While the melting point can not be taken as a certain indication of the purity of a lard, nevertheless a wide variation from 40° in the melting point of a lard should lead at least to a suspicion of its genuineness, or that it was made from a special part of the animal. Perhaps one reason why the melting point has not been more highly regarded by analysts is because of the unsatisfactory method of determining it; but when it is ascertained by the method used in these investigations it becomes a characteristic of great value.

Color reaction.—The coloration produced on pure lard by certain reagents serves as a valuable diagnostic sign in the analysis of lard and its adulterations. Various reagents have been employed for the production of characteristic colors in fats, but of these only two are of essential importance. They are sulphuric and nitric acids. Pure lard, when mixed with sulphuric and nitric acids of the proper density, as indicated hereafter, gives only a slight color which varies from light pink to faint brown. The variation produced in the color by pure lards is doubtless due to the presence in various quantities of certain tissues of the animal other than fat. For instance, a variation in the amount of gelatinous substance mechanically entangled with the lard or of the tissues composing the cells in which the lard was originally contained would be entirely sufficient to account for the slight difference in color produced by lards of known purity. It might, therefore, be difficult to distinguish accurately between a pure lard containing a considerable amount of other tissues from the animal and one which contained a small amount of adulteration. The coloration produced, therefore, by the acids named should not be relied upon wholly in distinguishing pure from adulterated lards; but the character of such coloration should be carefully noted in the analyst's book. In the steam lards examined some of the remarks describing the coloration produced are as follows:

"Trace of color," "faint pink," "bright pink," "light red," "yellowish," etc. For pure lards of micellaneous origin some of the de-

scriptions are as follows: "Brownish pink," "trace of yellow," "marked red brown," "no color," "slight coloration," etc.

Refractive index.—The deviation produced in the direction of a ray of light in passing through a film of melted fat is also a valuable physical characteristic. This deviation is usually measured as the quotient of the sine of the angle of incidence by the sine of the angle of refraction and is known as the refractive index. The refractive index of pure water, at 25° on the instrument used in these investigations, was 1.3300. The refractive index of the samples of lard was made at as low a temperature as possible to preserve fluidity, viz, between 30° and 36°. The rate of variation in the refractive index for each degree of temperature, experimentally determined, for lard oil was .000288. This number may also be taken to represent the variation for lard. The refractive index varies inversely as the temperature. The mean number for pure lard at 25° is about 1.4620. The refractive index of pure lard is distinctly less than that of cotton oil at the same temperature, and is therefore a valuable characteristic for analytical purposes.

Rise of temperature with H_2SO_4.—More valuable for diagnostic purposes than the physical property already considered is the rise of temperature which lard undergoes when mixed, under proper conditions, with sulphuric acid. There is such a marked difference between the numbers representing the rise of temperature in pure lard and those of the adulterations usually employed in the manufacture of mixed lard as to give this number a high analytical value. With steam lards, ten samples, the extremes, as registered by the thermometer, were 38.8° and 42.1°. For pure lards of miscellaneous origin, one from Deerfoot Farm, Southborough, Mass., gave a rise of temperature of 37.1°, and a pure leaf lard from Sperry & Barnes, New Haven, Conn., a rise of temperature of 46.2°.

The value of this characteristic is so great as to lead me to expect approximately reliable quantitative results from a general determination of the actual amount of heat produced in an appropriate calorimeter. I am at present attempting to devise an instrument by which the actual number of colories produced by mixing definite quantities of fats and oils and sulphuric acid can be accurately determined.

Crystallization point of fatty acids.—The method described in the work of Dalican for determining the crystallizing points of fatty acids gives valuable data concerning the nature of pure lard and also of the relative amount of stearic and oleic acids present in the mixture. In pure lards the crystallizing point was found to vary, in the ten samples of steam lard already mentioned, from 35.4° to 39.5°. In pure lards the variation was found to be from 32.1° to 42.7°.

Melting point of fatty acids.—In connection with the crystallizing point of the fatty acids, the temperature at which a thin disk of the same becomes a perfect sphere, otherwise known as the melting point, is also of value. This temperature has been determined in the fat acids derived from steam and pure lards. In the steam lards these numbers vary from 41.4° to 43°. In pure lards the variation was from 36.9° to 46.6°.

CHEMICAL PROPERTIES.

Volatile acids.—The quantity of volatile acid, as ordinarily estimated in pure lard, is extremely minute. Unless some suspicion of

adulteration is awakened the search for such volatile or soluble acid may be omitted. Measured in a quantity of deci-normal alkali solution for 5 grams of the fat the mean quantity of volatile acid in a pure lard may vary from .2 to .4 of a cubic centimeter. The determination, therefore, of the volatile acid in the examinations of lards has none of that high diagnostic value which attaches to it for the examination of butters.

Saponification equivalent.—The amount of caustic alkali necessary to saponify the fatty acids of the common glycerides is known as its saponification equivalent or number. The operation is usually known as Koettstoffer's process. The number of parts of a glyceride saponified by one molecule of alkali is represented by one-third of the molecular weight of the glyceride in question. The saponification equivalent, therefore, represents the number of grams of an oil or fat saponified by one equivalent in grams of an alkali. The percentage of caustic potash used for saponifying a lard is about 20 and the mean saponification equivalent about 285.

In the steam lards examined by us, leaving out one result of doubtful accuracy, the extreme variations were 276.14 and 290.05, and the mean 283.45. In pure lards the extremes were 272.64 and 294.14, and the mean 280.33.

Iodine number.—The quantity of iodine absorbed by an oil or fat affords one of the most valuable indications of its constitution. The glycerides of the oleine series have the property of absorbing the halogens. On the other hand the glycerides of the palmitic or stearic series do not absorb iodine. Hence in a fat or oil from which the presence of linoleine and its analogous body can be excluded the quantity of iodine absorbed may become a fairly accurate measure of the amount of oleic acid present. The lard derived from different portions of the swine varies largely in the amount of oleine contained therein. For instance, a sample of intestinal lard absorbed 57.34 per cent. of iodine; the leaf lard from the same animal absorbed 52.55 per cent.; the foot lard, 77.28 per cent.; the head lard, 85.03 per cent. In the steam lards mentioned the variation in the percentage of iodine absorbed was from 60.34 to 66.47 per cent., and the mean 62.86 per cent. In pure lards the mean was 62.45 per cent. Thus in lards of known purity the amount of iodine absorbed will indicate the probable part of the animal from which the fat in the lard was derived. The wide variation between the iodine numbers of pure lard and those of the adulterants used in making refined lard serves to render this number of the greatest importance in analytical work.

The reaction with nitrate of silver.—Pure lards treated with a solution of nitrate of silver after the method of Bechi, or the fatty acids thereof after the method of Milliau, give no reduction of metallic silver, or at most only a trace or slight coloration. This fact is of the utmost importance in the analysis of lard.

Microscopical appearances.—Lard examined with the microscope shows a definite crystalline structure but does not plainly reveal the character of the crystals. When lard is slowly crystallized from a mixture of ether, beautiful rhombic crystals of stearine are obtained which are easily distinguished from the groups of fan-shaped crystals given by beef or mutton fat under similar conditions.

Moisture in lard.—The quantity of water in pure lard varies from a mere trace to .2 per cent.

PROPERTIES OF LARD ADULTERANTS.

COTTONSEED OIL—PHYSICAL PROPERTIES.

Specific gravity.—Cottonseed oil being liquid at ordinary temperatures its specific gravity can be easily taken at the temperature of the room. For purposes of comparison the rate of variation in the specific gravity of the oil can be determined, and its specific gravity at any given temperature calculated; or its specific gravity can be directly determined at 35°, 40°, or 100°, as may be desired. In the samples examined the specific gravities of the oils at 35° vary from .9132 to .9154. The mean for nineteen samples is .9142. These numbers show the relative weight of the oil and equal volumes of water at the same temperature, the weight of water being taken as unity.

Melting point.—Since cotton oil solidifies only at a temperature near or below the freezing point of water its melting point has not been determined.

Color reaction.—The color produced in cotton oil by sulphuric and nitric acids is a characteristic mark of the greatest value. This color varies from deep reddish brown to an almost black color. Some of the descriptions of the color produced in cotton oil, taken from the note-book, are as follows: "Dark brown," "very brown black," "deep red brown," "very red," "yellow brown," etc. It must not be forgotten, however, that these colors can be produced by other oils, and hence their occurrence is not conclusive of the presence of cotton oil.

Refractive index.—The refractive index of cotton oil is distinctly higher than that of lard. The variation in the index of refraction is inversely as the temperature. The mean rate of variation for each degree is .000288. For a temperature of 25° the mean refractive index of the samples examined was 1.4674. The rate of variation in the index of refraction in cotton oil is sensibly the same as that for lard.

Rise of temperature with sulphuric acid.—The rise of temperature which cotton oil suffers when mixed with sulphuric acid is a very prominent diagnostic sign. In the samples examined, the lowest increment of temperature noted was 80.4° and the highest 90.2°. The mean rise of temperature was 85.4°. Cotton oil therefore gives more than double the increment of temperature shown by pure lard under the same conditions.

Crystallization point of fatty acids.—Since cotton oil is fluid even at low temperatures (viz, 0°), the determination of its melting point is only a matter of scientific interest. The point at which its free acids crystallize is, however, easily determined, according to the method of Dalican.

The mean crystallizing point of the acids examined was 33.6°, the minimum was 30.5°, the maximum was 35.2°.

Melting point of fatty acids.—The melting point of the free acids of cotton oil was determined both in capillary tubes and by observing the deportment of the acid on the bulb of a delicate thermometer protected by a glass flask. The two sets of data were almost identical.

The mean melting point of the acids examined was 39.3°, the maximum was 44.4°, the minimum was 34.6°.

CHEMICAL PROPERTIES.

Volatile acids.—The statements made in regard to the volatile acids in a pure lard are also applicable to cottonseed oil. For 5 per

cent. of cotton oil the quantity of $\frac{N}{10}$ alkali consumed is slightly greater than for pure lard and may amount to as much as .5 c. c. If cocoa oil is present the number will be much higher. Five per cent. of pure cocoa oil will consume from 7 to 8 cc of the deci-normal alkali.

Saponification equivalent.—In the samples examined, the mean saponification equivalent was 283.8, although in some instances quite a difference was noticed from this figure.

Iodine number.—Cotton oil possesses in a much higher degree than lard the property of absorbing iodine. This is due not only to the large percentage of oleic acid which it contains, but also probably to the presence of a small amount of linoleic acid or some homologue thereof. In the samples examined, in no case did the iodine number fall below 100 and in one instance it rose to 116.97. The mean iodine was 109.2.

Reaction with nitrate of silver.—A more important property even than its power of absorbing iodine is shown by cotton oil in the reduction of silver to the metallic state under certain conditions.

The test may be applied, as already indicated, either to the oil itself or to the fatty acids thereof. The silver is either reduced in the form of a metallic mirror deposited on the sides of the vessel or in minute black particles which give a brown or black appearance to the liquid. In some cases the liquid shows a greenish tint.

Other properties.—The refined cotton oil used in adulterating lard has a pleasant taste, is almost odorless, and possesses a faint yellow color. Its resemblance to olive oil is so marked that for all culinary purposes it forms an excellent substitute therefor. Cotton oil possesses slight drying qualities, which render it unfit for lubricating machinery. It can never take, therefore, the place of sweet oil for that purpose.

PREPARATION OF COTTON OIL.

The cotton seed from various sources is put through a screen to take out the bolls and coarse material. The seed is then put through a gin to remove as much as possible any remaining lint, of which about 20 pounds per ton of seed are obtained.

The clean seed is next sent to a huller composed of revolving cylinders covered with knives which cut up both seed and hull. The chips are then conveyed to the screen placed on a vibrating frame, through which the kernels fall. The hulls are carried by an endless belt to the furnaces where they are burned. The kernels of the seed are conveyed to crusher rolls, where they are ground to a fine meal. The meal is then sent to a heater where it remains from twenty to forty minutes. These heaters have a temperature of 210° to 215°. The hot meal is formed into cakes by machinery. These are wrapped in cloth and placed in the press. About 16 pounds of meal are put in each cake. The cakes are placed in a hydraulic press, where a pressure of from 3,000 to 4,000 pounds per square inch is applied. The press is also kept warm. The expressed cake contains only about 10 per cent. of oil. The cake is sold as cattle food or for fertilizing purposes. The crude oil as thus expressed contains 1.5 per cent. of free acid. The chief cotton-seed presses of the country are located at the following points:

COTTONSEED OIL MILLING POINTS.

Arkansas—Little Rock, Argenta, Fort Smith, Texarkana, Brinkley, and Helena.

Alabama—Selma, Mobile, Montgomery, Eufaula, and Huntsville.
Georgia—Atlanta, Augusta, Albany, Columbus, Macon, and Rome.
Tennessee—Memphis, Jackson, Nashville, and Dyersburgh.
Texas—Brenham, Dallas, Galveston, Houston, Palestine, and Waco.
Illinois—Cairo.
Louisiana—New Orleans, Shreveport, Baton Rouge, and Monroe.
Missouri—Saint Louis.
Mississippi—Clarksdale, Columbus, Canton, Grenada, Greenville, Meridian, Natchez, Vicksburg, and West Point.
North Carolina—Charlotte and Raleigh.
South Carolina—Columbia and Greenville.

The oil is chiefly pressed in winter, since it is difficult to keep it for summer work; some mills are, however, operated during the summer. The crude oil is shipped in tanks holding from 36,000 to 45,000 pounds each. When the oil is shipped north in winter it usually becomes solidified. In order to get it out of the tanks they are placed on switches and a jet of steam is introduced into the tank and the oil gradually melted out. Another method consists in covering the tank with wood, forming a chamber, into which exhausted steam is introduced. Gutters are provided along the railroad tracks into which the oil flows, and is conducted into the receiving tanks. From the receiving tanks it is pumped into large receivers called scale tanks, where the crude oil is weighed.

Refining process.—After weighing the oil is pumped into refining kettles. These are of various sizes, the largest ones being 20 to 25 feet deep and 15 feet in diameter. These tanks are furnished with steam coils for the purpose of heating the oil and with appropriate machinery for keeping it in motion. A solution of caustic soda is used for refining. This solution is made from 10° to 28° Baumé in strength and various quantities are used according to the nature of the oil operated upon. After the addition of the caustic soda the mixture is agitated for forty-five minutes and kept at a temperature of 100° to 110° F. The contents of the tank are then allowed to stand six to thirty-six hours when the solid matters, soap, and substances precipitated by the caustic akali gather at the bottom. This mixture is called foots and is used for making soap. The yellow oil resulting by this process is purified by being heated and allowed to settle again or by filtration and is called summer yellow oil. Winter yellow oil is made from the above material by chilling it until it partially crystallizes and separating the stearine formed, about 25 per cent., in presses similar to those used for lard. This cotton-oil stearine is used for making butterine or soap.

White oil.—The yellow oil obtained as above is treated with from 2 to 3 per cent. of fuller's earth in a tank furnished with apparatus for keeping the mixture in motion. When the fuller's earth has been thus thoroughly mixed with the oil the whole is sent to the filter press. The fuller's earth has the property of absorbing or holding back the yellow coloring matter so that the oil which issues from the press is almost white. This white oil is the one which is chiefly used for making compound lard.

Stearines.—The stearines used in the adulteration of lard are derived chiefly from lard, tallow (suet), and cotton oil. These are generally called oleo stearine, lard stearine, and cotton-oil stearine, respectively.

PHYSICAL PROPERTIES.

Specific gravity.—The specific gravity of stearines may be taken in their solid state or in a liquid state at a high temperature, best at 100°. The numbers are slightly lower than those for lard.

Melting point.—The melting points of the stearines are higher than the natural glycerides from which they are derived. A prime oleo stearine from Armour & Co., Chicago, showed a melting point of 51.9°. A prime lard stearine from the same firm showed a melting point of 44.3°, which is only slightly higher than the mean melting point of pure lards. The lowest melting point of any stearine examined was a sample of dead-hog stearine from J. P. Squire, Boston, which was 38.2°. The highest observed melting point in the stearines examined was an oleo stearine from N. K. Fairbank & Co., Chicago, showing 53.8°. The high melting point of the stearines is a characteristic of great value in the adulteration of lard, since it serves to counteract the influence of the cotton oil, which of course tends to lower the melting point of any lard mixture into which it may enter. The influence of the various constituents, however, on the melting point does not seem to be proportional to the respective quantity of each therein. For instance, a mixture of 25 per cent. of cotton oil having a melting point about zero, with 25 per cent. of an oleo stearine having a melting point of only about 12° above the normal for pure lard, with 50 per cent. of pure lard of normal melting point, might not show a lowering of the melting point at all proportional to the presumable influence of the cottonseed oil present. The cotton-oil stearine, as might be expected, has a melting point very much below that of the similar products derived from lard and tallow.

Color reaction.—The color reactions produced in the stearines by sulphuric and nitric acids are much the same as those produced in the original glycerides from which they were derived. Cotton-oil stearine shows a less intense color perhaps than the original oil; while in the case of tallow and lard stearines the coloration is not marked enough to be susceptible of description.

Refractive index.—The refractive index of the stearines is sensibly lower than that of the original glycerides. The refractive index of a prime lard stearine from Fairbank & Co. was found to be 1.4555 at 29.9°; of a white cotton-oil stearine from a Southern cottonseed oil company the refractive index was 1.4645 at 29.8°.

Rise of temperature with sulphuric acid.—With the lard and tallow stearines no degree of comparison can be made in the rise of temperature with that produced in the original glycerides, on account of the high initial temperature which is necessary for the conduct of the experiment. Allowing for the difference in initial temperature, however, the stearines deport themselves very much as the glycerides from which they are derived.

CHEMICAL PROPERTIES.

Volatile acids.—The amount of volatile acids in the stearines mentioned is so small as to be negligible.

Saponification equivalent.—The numbers are essentially the same as those of the original glycerides.

Iodine number.—The percentage of iodine absorbed by the stearines is, as is to be expected from the fact that they contain less triolein, markedly less than that of the original glycerides. The fact

that the stearines possess that property in this diminished degree is of quite as much importance from an analytical point of view as their high melting point. Thus the mixture of a stearine with a low iodine number with cotton oil of a high iodine number shows a percentage of iodine absorption not markedly different from that of pure lard. One prime oleo stearine examined showed an iodine absorption of only 17.38 per cent. Another oleo stearine showed 26.81 per cent. The lard stearines showed higher numbers, viz, in two cases 44.24 per cent. and 49.78 per cent. The cotton-oil stearines showed iodine numbers varying from 85.28 per cent. to 99.39 per cent.

Reaction with nitrate of silver.—The stearines react with nitrate of silver in a manner entirely comparable with that of their original glycerides.

Microscopical appearances.—Stearine derived from beef or mutton tallow shows under the microscope the characteristic fan-shaped crystals already noticed. Lard stearine on the other hand gives crystalline groups similar to those already mentioned in the case of lard.

Moisture.—Properly prepared stearine contains only a trace of moisture.

Other adulterants of lard.—It has been claimed that other substances than those mentioned have been used in the adulteration of lard, but these claims seem to rest on no valid foundation. Among these substances dead-hog grease or dead-hog stearine is the one most frequently mentioned. The term dead-hog grease is used to indicate the oil or lard obtained from animals which die of disease or are smothered in transportation or die on the way to the slaughtering houses. The fat of animals very recently dead, unless death takes place from disease, and taken before any decomposition sets in has chemically the same characteristics as that derived from animals slaughtered. If, however, the animals have been dead some time before rendering a considerable decomposition of the glycerides takes place and the amount of free acid in the fat is thus largely increased. Such fat also shows a distinctly unpleasant odor by which it can readily be distinguished from genuine lard. Peanut oil and some other vegetable oils have also been mentioned as adulterants of lard. While it may be true that many attempts have been made to use the above substances in the adulteration of lard on a small scale, it is also quite true that such attempts have never attained any importance from a commercial point of view.

Mixing.—The term "refined lard" has long been used to designate a lard composed largely of cotton oil and stearine. The largest manufacturers of this kind of lard have now abandoned this term and are using the label "lard compound" instead. This is but just to the consumers of this article who are likely to be misled by the term "refined lard." The prime steam lard in a state of fusion, the stearine, also in a liquid condition, and the cotton oil are measured in the proportions to be used and placed in a tank at a temperature of 120° to 160° Fahr. In this tank the ingredients are thoroughly mixed by means of paddles operated by machinery. After mixing the compound lard passes at once to artificial coolers where it is chilled as soon as possible; it is thence directly run into small tin cans or large packages and prepared for market.

PROPERTIES OF ADULTERATED LARDS.

In external appearance to an unskilled person adulterated lards are not appreciably different from the pure article. An expert, however,

is generally able to tell by taste, odor, and grain a mixed lard from a pure one. There is usually enough lard in the adulterated article to give to it the taste and odor of a genuine one. Mixtures of fat, however, have been made, and perhaps sold as lard, which contained no hog grease whatever. In the following descriptions an endeavor has been made to give the chief characteristics of an adulterated lard on the same plan as the descriptions of pure lard and the adulterants thereof which precede.

PHYSICAL PROPERTIES.

Specific gravity.—But little stress can be laid upon the numbers representing the specific gravity of adulterated lards, since the materials of which they are composed have nearly the same specific gravity as the pure article. The addition of cotton oil, however, raises the specific gravity, and when this substance is present in quantities above 15 per cent. its influence on the specific gravity of the sample is marked. At 35° the specific gravity of adulterated lards varies from .906 to .910.

Melting point.—The melting point of the adulterated lards is in some cases slightly lower than that of pure lards. This arises from the fact, which has already been noticed, of the low melting point of the cotton oil, which is one of the principal adulterants used. The numbers representing the melting points of adulterated lards, emphasize the fact, which has already been noted, that the lowering of the melting point is not theoretically proportional to the contents of cottonseed oil found in the adulterated lards of commerce. In a number of samples of lards containing cottonseed oil from Fairbank & Co. the lowest melting point was 31.3° and the highest 41.9°. In the series of samples from Armour & Co. the lowest melting point noticed was 38.9° and the highest 43°3°. The melting point of the Armour samples approaches much nearer that of pure lard than those received from Fairbank & Co. Although the melting point is not of itself a property of very great importance from an analytical point of view, yet its determination should never be neglected in a comprehensive analytical examination.

Color reaction.—The amount of coloration shown by an adulterated lard, when treated with sulphuric or nitric acid, depends upon the percentage of cotton oil which it contains, since from a commercial point of view the introduction of a small amount of cotton oil would not prove profitable. We find in the adulterated lards of commerce, as a general rule, strong color reactions. It might be possible, however, to mix with a pure lard so small a quantity of cotton oil as to render doubtful to the analyst the character of the color reaction produced. Some of the colors produced in the adulterated lards examined, as copied from the note-books, are as follows: "Light brown," "pink red brown," "light yellow red," "light pink," "deep brown," "red," "deep red brown," etc. The appearance of a pinkish tint is often found in adulterated lards containing a notable portion of beef-fat stearine, although this coloration is not considered a certain indication of the presence of this substance.

Refractive index.—The refractive index of the mixed lards naturally varies with the proportion of cottonseed oil which may be present. The greater the quantity of cottonseed oil the higher the refractive index. The refractive index of the Armour mixed lards is decidedly lower than that of the Fairbank samples. The following is the number representing the mean refractive index of the Ar-

mour samples at 25°, viz, 1.4634. The number representing the mean refractive index of the Fairbank samples is 1.4651. The refractive index is a much more important property in the sorting of lards than the melting point, or perhaps even than the specific gravity.

Rise of temperature with sulphuric acid.—As is to be expected we find here also the greatest variations depending on the nature and the quantity of the adulterants present. The presence of tallow stearine tends to diminish the rise of temperature with sulphuric acid, while cottonseed oil has the opposite effect. As the relative proportion of these two ingredients and also the amount of pure lard varies we may expect corresponding variation in the temperature shown on mixing the lard with sulphuric acid. In the samples of Armour's lards examined the highest rise of temperature noticed was 58.9° and the lowest 42.1°. This latter number is almost identical with that furnished with pure lards. In Fairbank's lards the least rise of temperature noticed was 51.3° and the greatest 68.8°. These numbers show a larger proportion of cotton oil in the Fairbank than in the Armour samples. This rise of temperature as a diagnostic sign is valuable and its determination should never be omitted.

CHEMICAL PROPERTIES.

Volatile acids.—The remark which has been made in regard to the volatile acids of pure lards and their adulterants is also applicable for mixed lards. The amount is so minute as to be of no value from an analytical point of view.

Saponification equivalent.—The numbers representing the saponification equivalent do not afford any particular indication of the kind of adulteration used. In the samples of Fairbank mixed lards examined, the mean saponification equivalent found was 279.4. In the Armour samples it was 275.

Iodine number.—The amount of iodine absorbed by a mixed lard gives a valuable indication of the kind of the ingredients which have been added to it. It has already been seen that the stearines, especially those derived from tallow, have a very low iodine number, while cottonseed oil has a very high one. It is therefore possible to mix these two substances together so that the resulting iodine number may be about the same as that of pure lard, viz, 60 per cent. In the samples of the Armour mixed lards examined the mixture seems to have been made in about the proportion indicated. The lowest iodine number observed in these lards was 54.11 per cent., which is decidedly less than that of normal pure lard. The highest number observed was 71.19 per cent. The other numbers were slightly above those obtained for pure lard. In the samples of mixed lards from Fairbank & Co. the iodine numbers are much higher. The lowest number observed was 78.24 and the highest 94.78 per cent.

Reaction with nitrate of silver.—Mixed lards containing cotton oil show a reduction of metallic silver in a greater or less degree according to the proportion of cotton oil present. In every case where cotton oil was known to be present in a mixed lard this reaction was noticed. It would be possible, however, to put so small a portion of cotton oil into a lard as to render difficult the positive detection of it by the nitrate of silver test.

Microscopic appearances.—The mixed lards show in the field of vision of the microscope distinct tufted crystals of the stearines which have been used as adulterants. The rhombic crystals of pure

lard are also often noticed in this field. The microscope is a most valuable aid in detecting lard adulterations.

Moisture in mixed lards.—Mixed lards generally contain only a trace of water. In one instance, however, water appears to have been added as an adulterant, over 30 per cent. of it having been found. The use of water as an adulterant of lard, however, is not common.

COMPARISON OF PROPERTIES OF LARDS AND COMPOUND LARDS.

The mean results of the analytical data are as follows:

Kind of samples.	Specific gravity.	Saponification equivalent.	Melting point of the glycerides.	Melting point of the fat acids.	Crystallizing point of fat acids.	Rise of temperature with sulphuric acid.	Percentage of iodine absorbed.	Refactive index.
			C°	C°	C°	C°		
Pure lard	.9053	280.3	40.7°	43.8°	39.6°	41.5°	62.48	1.4620
Lard of miscellaneous origin	.9067	274.4	41.7°	42.9°	39.6°	45.7°	64.34	1.4633
Prime steam lard	.9055	283.5	37.0°	42.1°	38.6°	39.9°	62.86	1.4623
Armour's lards	.9060	275.0	40.6°	42.8°	39.8°	46.5°	63.58	1.4634
Fairbank's lards	.9095	279.4	38.1°	40.6°	37.4°	57.9°	85.31	1.4651

STATISTICS OF THE LARD INDUSTRY.

It was developed in the investigations before the Committees on Agriculture of the Senate and House of Representatives that the annual production of lard in the United States is 600,000,000 pounds, of which about half is pure lard and the other half pure lard mixed with stearine and cotton oil, the "refined" or compound lard of commerce. The annual exports of lard are about 320,000,000 pounds, of which about 40 per cent. were compound or refined lard.*

According to the figures furnished by the Bureau of Statistics the production of lard from 1877 to 1887, inclusive, is as follows:

Years.	Total.	Years.	Total.
	Pounds.		*Pounds.*
1886-'87	527,032,000	1881-'82	468,929,000
1885-'86	514,230,000	1880-'81	517,660,000
1884-'85	480,405,000	1879-'80	479,020,000
1883-'84	444,450,000	1878-'79	514,295,000
1882-'83	419,513,000	1877-'78	404,572,000

The exports from 1873 to 1888 are shown by the following numbers:

Years.	Lard exported.	Years.	Lard exported.
	Pounds.		*Pounds.*
1873	234,901,511	1881	335,001,686
1874	184,100,226	1882	239,904,657
1875	167,579,377	1883	273,286,610
1876	198,008,212	1884	228,165,733
1877	237,744,307	1885	301,305,105
1878	345,693,527	1886	298,083,094
1879	343,119,208	1887	324,515,224
1880	405,437,658		

* Statement of Mr. G. H. Webster before House Committee on Agriculture, report of hearings, p. 26.

If we take the percentage of cotton oil in the compound lard at 40, the total weight of oil used in manufacturing mixed lard is 120,000,000 pounds.

In addition to this large quantities of cotton oil are used for salad dressing and culinary operations, and in the manufacture of a substitute for lard (cotolene) which contains no hog grease whatever.

EXPERIMENTS IN THE MANUFACTURE OF SUGAR.

Assignment of work.—The bill making an appropriation for experiments in the manufacture of sugar did not become a law until the 19th of July, 1888. At that time it was manifestly impossible for the Department to make any arrangements of its own for the conduct of experiments during the present manufacturing season. It was necessary, if any experiments be made at all, that they should be arranged for in connection with work already in progress, either by individuals, private corporations, or State experiment stations. The following arrangements were therefore made for the experimental work:

(1) A continuation of the experimental work at Rio Grande, N. J., under the direction of Mr. H. A. Hughes.

(2) A series of experiments at Kenner, La., under the direction of Prof. W. C. Stubbs.

(3) Experimental work at Douglass, Kans., under the direction of the Douglass Sugar Company.

(4) Experimental work at Conway Springs, Kans., under the direction of Mr. E. W. Deming.

(5) Experiments in the improvement in the varieties of cane at Sterling, Kans., under the direction of Mr. A. A. Denton.

In addition to the above work, arrangements were made for analytical researches under my direction at Douglass, Conway Springs, and Sterling, Kans. It was deemed unadvisable, at the late date mentioned, for the Department to suggest any experimental work or assume any control thereof. Having been authorized to arrange for such work in a manner which seemed most advantageous, the following directions were given: The work at Rio Grande was placed exclusively in charge of Mr. H. A. Hughes, to be conducted in such manner as he saw fit for the benefit of the industry. The work which Mr. Hughes proposed to do was on a small scale, with the ultimate idea of making it possible for farmers and others to manufacture sugar without the expense of apparatus usually considered necessary for that purpose. The results of Mr. Hughes's work have been reported by him further on, and a discussion of them will be given in connection with his report.

Prof. W. C. Stubbs having commenced preparations for experimental work with sorghum at the experiment station at Kenner, he was authorized to complete this work under the auspices of the Department. No instructions in regard to the method of performing the work were sent to Professor Stubbs except to do that which seemed best for the promotion of the industry. His report of the results of the work and the discussion thereof will follow.

The experimental work at Douglass, Kans., was placed under the control of the Douglass Sugar Company. Its object was to test thoroughly the method of open diffusion practiced on a small scale by Mr. Hughes at Rio Grande, and they conducted the work under the general instructions to give that system of diffusion and the appa-

ratus a thorough and impartial test. The general results of the experimental work at the station are given in the report of Mr. Edson, with a discussion of the data there recorded.

The experimental work at Conway Springs consisted in the trial of a new system of preparing the exhausted chips for fuel, and certain new arrangements of apparatus connected with the diffusion battery and of a new system of handling and storing the cane. No specific instructions were given to Mr. Deming in regard to the conduct of the work, but he was left free to use his own judgment in every particular in regard to what was best to be done. Mr. Deming's report and the discussion thereof will follow.

The experimental work at Sterling was of an entirely different order. The Sterling Sugar Company had commenced a thorough examination of all obtainable varieties of the sorghum plant. By an arrangement made with this company the Department assumed this work in the condition in which it was found the latter part of July and carried it to completion under the supervision of Mr. Denton. Mr. Denton's report and observations thereon will follow.

The following assignment of the chemical force of the Division was made for the purpose of securing analytical data of the season's work:

Mr. Hughes having expressed an opinion that he could get along independently of any chemical assistance from the Department, no assignment was made to Rio Grande. Mr. Edson was placed in charge of the chemical work at Douglass, assisted by Mr. John L. Fuelling. Prof. E. A. von Schweinitz was placed in charge of the chemical work at Conway Springs, assisted by Mr. Oma Carr. Dr. C. A. Crampton was placed in charge of the work at Sterling, assisted by Mr. Karl P. McElroy.

In the latter part of July I visited the three localities last named and arranged with the proper persons for the establishment of the laboratories and perfected the arrangements for the chemical control which was desired. In September and October I visited each of the laboratories above mentioned and spent some days with the chemists in charge in consultation concerning the progress of the work and any changes or alterations therein which seemed necessary. The results of the chemical work in each case will be found in connection with the reports of the respective stations.

Experiments at Rio Grande, N. J.—The result of the work at Rio Grande is disappointing in its nature. For some reason the cane grown in that locality has failed to improve, although it appears that it has had the benefit of careful attention and fertilization. There has been upon the whole, as indicated in Bulletin 18, a deterioration of the cane at Rio Grande; the crops which were raised six or seven years ago showing a higher percentage of sucrose than those of the present time. This deterioration has been caused either by admixture of a non-saccharine variety with the seed, by the method of culture or by the influence of the soil and climate of that locality. I am inclined to attribute much of the depreciation to a fault of the seed; whether or not it has been mixed with broom corn I am unable to say. The almost total failure of the Amber cane at Rio Grande would seem to indicate that some such accident had happened to it. While Amber cane in other localities has continued to show a high percentage of sucrose in the juice, at Rio Grande it has become a worthless variety for sugar-making or even the production of sirup. The importance of seed selection is emphasized by this fact, since there is every reason to believe that if seed of the Early Amber, such

as was planted at Rio Grande seven or eight years ago, were again planted in that locality it would produce an equally rich crop of cane. It would be a useless task, however, for any one to attempt the successful manufacture of sugar by any process from juices no richer than those reported by Mr. Hughes during the present year; such cane at best could only make molasses and that probably of an inferior character. These agricultural results are the more discouraging because of the systematic attempts which have been made at Rio Grande in conjunction with the New Jersey experiment station for the production of a high-grade cane; these are not, however, sufficiently discouraging to justify abandonment of similar attempts in other localities. In respect of the climate at Rio Grande I can see nothing which would lead me to believe that it is unfavorable to the growth of sorghum. On the other hand, the climatic conditions appear extremely favorable unless it be true that sorghum will not develop a maximum content of sugar in localities favored with abundant summer rains. Aside from this the favorable conditions for growth and the practical immunity from early frosts render the locality a most favorable one for the production and manufacture of a crop of sorghum cane. The soil of this locality, it is true, is not naturally as fertile as the soils of Kansas, but with the judicious fertilization which has been practiced the tonnage per acre has been fully as great if not greater at Rio Grande than in most other localities.

In regard to the methods of manufacture employed at this station it is necessary to speak with some degree of caution. In the report of Mr. Hughes we have, from his stand-point, a brief but graphic description of the method employed. I have never been of the opinion that sugar-making from sorghum could be successfully practiced on a small scale, and the experiments carried on by the Department of Agriculture for two successive seasons at Rio Grande have only served to confirm me in this belief. The nature of the processes employed, the character of machinery required, and the kind of skilled labor needed, all combine to render the manufacture of sugar on a small scale commercially unsuccessful. I do not see any favorable result in this direction from the two years' trial at Rio Grande.

For the present manufacturing season Mr. Hughes does not give the total amount of sugar made except from a portion of the crop; and this is no evidence whatever that its cost has been sufficiently low to enable it to be put upon the market in competition with other sugars. I should have been glad had the result been otherwise, for the successful inauguration of an era of sugar-making conducted by farmers would have been a great blessing to vast agricultural regions.

In regard to the machinery employed my opinion has already been expressed. I have said repeatedly, both in official publications and in other places, that I regarded the system of cutting and preparing the cane devised by Mr. Hughes, and now in use in every sorghum factory in the United States and in at least one cane-sugar factory, as the very best which has yet been invented. I have long been convinced that for the extraction of sugar from cane of both kinds the greater the degree of comminution of the chips the more successful the process will be. The system of double shredding inaugurated by Mr. Hughes during the past season tends to secure this end. It was in this direction also that I urged last year for sugar cane the construction of a shredding machine on the principle of the shredder

built by the Newell Universal Mill Company of New York, for the purpose of preparing the pieces of cane properly for the diffusion battery. This shredder I suggested should be furnished with very fine steel knives of the general pattern of the shredder now in use, with short cylinders of large diameter driven at a very much higher rate of speed. Last year I suggested to Mr. Fiske, the inventor of the machine above mentioned, the advisability of building such a machine in duplicate for the purpose of reducing the cane to as fine pieces as possible. The advantage of such a shredder as this over the one used by Mr. Hughes would be principally in its greater strength and in the assurance that it could be run for days, and perhaps a whole season through, without any necessity for repairs. It is of the highest importance that the apparatus for cutting and pulping the cane should be as effective as possible and built in two sets, so that if one should be out of order the second could still be used.

In regard to the system of diffusion practiced at the Rio Grande station and described in Bulletin 18, further experience only leads me to emphasize what has been said in that bulletin, viz:

> The defects of the system were both mechanical and chemical. The mechanical difficulty is the same as that which attends all methods of diffusion in which the cane chips are moved instead of the diffusion liquors. From a mechanical point of view, it is far easier and more economical to move a liquid in a series of vessels than a mass of chips. In the Hughes system the whole mass of chips undergoing diffusion, together with adhering liquor, and baskets and suspending apparatus, are lifted vertically a distance of several feet, varying with the depth of the diffusion tanks, every few minutes. The mechanical energy required to do this work is enormous, and with large batteries the process would prove almost impossible.

The truth of this view will be further illustrated in the report of the Douglass Sugar Company. For very small batteries working only a few tons a day this system might possibly be employed, but I doubt even then if it could be economically worked. This opinion of mine, as will be seen, is at total variance with that expressed by Mr. Hughes, and those who propose to become practically interested in the matter will have to decide upon the merits of the two systems of diffusion after a personal investigation.

Mr. Hubert Edson, who has had two years' experience with the open system of diffusion, made the following statements relating thereto in the *Louisiana Planter and Sugar Manufacturer* of December 1, 1888.

This report refers to the battery used at Douglass, Kans., during the season of 1888:

> The battery was built from plans secured directly from Mr. Hughes, and with one or two slight changes was worked throughout the season. The main battery consisted of ten cells, open at the top to admit the baskets in which the chips were placed for diffusion. These baskets, made of strong boiler iron, were attached to the arms of a crane, which was raised, rotated, and lowered till the requisite number of immersions was obtained. Besides these ten cells there was an extra one of the same dimensions placed just outside and within reach of the arms from the larger crane. This arrangement was intended to secure a dense diffusion juice, allowing, as the diffusion progressed, the heaviest juice from two of the cells of the main battery to be drawn into the outside cell, and which there received two baskets of fresh chips before being emptied.
>
> This manner of operating the battery will, it is claimed by the inventor, give a juice almost as dense as a corresponding mill juice. In my opinion, however, no greater advantage is secured by the eleventh cell being outside the main battery than by the same number arranged in regular order. Certainly, at Douglass, the results claimed by the inventor were not even approximated. The outside cell also entailed an extra amount of labor in transferring the basket from the small crane to which it was attached during its immersion to the large crane of the main battery.

So much for the manner of working the battery. Now for the things that are of actual value to the sugar planters—the results obtained and the expenses incident to such results,

Machinery of any kind to be effective should require a minimum of human labor. Let us see how the Hughes battery compares with the ordinary form. At Douglass the battery was designed to work a hundred tons of cane daily, and to do this at least eight men were necessary to shift the baskets to their different places. Half of this number would run a closed battery and find the work easier, since they would have no baskets weighing a thousand pounds each to handle.

Besides this manual labor the whole ten baskets had to be raised every time one was filled or emptied. A large hydraulic pump is used for this work and of itself requires more power than is necessary to run a battery of closed cells. This extra power and labor would not necessarily condemn the apparatus, if such superior results were obtained as to overcome the expense. But instead of this exactly the reverse was accomplished. Not much better extraction was secured than is obtained by the ordinary cane-mill of Louisiana, and this only with a dilution of nearly 50 per cent., causing an extra expense of no small amount of evaporation. Then also the quality of the juice obtained was extremely poor. The almost constant exposure to the air and especially in iron vessels blackened it to such a degree that no good sugars could be made from it. Clarification was nearly impossible with any of the ordinary re-agents in the sugar-house. This was extremely unfortunate in Kansas, as the greatest profits are made on material sold to the home market.

Experiments at Kenner, La.—As has been mentioned before, Prof. W. C. Stubbs was placed in charge of the experiments which were arranged for in connection with the Louisiana sugar experiment station at Kenner and the stations at Baton Rouge and Calhoun. For two previous seasons Professor Stubbs had made extensive experiments with sorghum, which are fully reported in the bulletins of the Louisiana experiment station and in Bulletin No. 18 of this Division. A study of the analytical data of the three years' work in Louisiana shows in an emphatic way the peculiarities of sorghum which have rendered so difficult the successful inauguration of sugar-making from that plant. The great variations in the content of sucrose in the juices of the plant, its susceptibility to injury by storms and other unforeseen causes, are strikingly set forth in the analytical figures which follow. In my opinion the production of a variety of sorghum cane suitable to the soil and climate of the sugar lands of Louisiana will be a work of no small difficulty. From the results of the work already done, and especially during the last year, an account of which is contained in the appended report of Professor Stubbs, it is clearly seen that a season which has produced a sugar cane very rich in sucrose in the State of Louisiana has produced a sorghum crop which is absolutely worthless for sugar-making for commercial purposes. Another point illustrated by the report is brought out in reference to the past work of the station in which, although a cane was produced whose juice was reasonably rich in sucrose, its practical working in the sugar factory was found most difficult. In the report this is ascribed to the presence of large quantities of dextrine or dextrine-like bodies supposed to be derived from the starch originally present in the juice. It is the opinion of Professor Stubbs that starch and sucrose are developed in the sorghum *pari passu*. In this case it would be found that the direct polarization of a sorghum juice rich in sugar would show apparently a much higher content of sucrose than was actually present, since dextrine and its allied bodies are much more dextrogyratory than sucrose. The points developed by the experiments may be summarized as follows:

(1) Sorghum cane develops sometimes in Louisiana a juice containing a very high percentage of sucrose, but combined with other bodies which render its separation from the juice difficult.

(2) The occurrence of a wet summer attended by the severe wind storms which are so common in that locality prevents the development of a high sucrose content in the growing sorghum.

(3) The possible utilization of sugar machinery for a longer manufacturing season is one of the chief inducements in the sugar-cane regions for the cultivation of sorghum as a sugar-producing plant.

(4) Delay in working the cane after cutting is not as dangerous as has been supposed.

It will be understood that these are conclusions which I have drawn from reading Professor Stubbs's report, and are not formulated in the above manner by himself. Some of these conclusions do not seem to me to be justly drawn from the data at hand.

The results of the attempts to grow sorghum for sugar-making purposes on the low sugar lands in Louisiana in my opinion are not highly encouraging to the belief that these lands and their climate are the best suited in the United States for the production of sorghum as Professor Stubbs says. On the other hand I believe there are few localities in the United States where sorghum grows at all in which a better crop for sugar-making purposes can not be produced. Experience has shown that the dry climate of southern and western Kansas produces the most uniform crop of sorghum for sugar-making purposes, while the data of Professor Stubbs which follow show that the Louisiana product, for the present year at least, is about the poorest on record. One point, however, should be borne in mind, viz, that the course of experiment pursued by the Louisiana experiment station is the one which is best suited for the rapid development of every possibility of sorghum culture in that State. The experimental trials which are made with sorghum will show both its weak and strong points, and in the wide variation which the plant shows there will doubtless be some variety produced or found which will be best suited to the peculiar conditions which obtain in that locality. The soil and climatic conditions of the northern part of the State where cotton is now grown will probably be found better suited to the production of sorghum than those of the present sugar-producing localities. I feel quite sure that the expectation expressed by Professor Stubbs of being able to realize under certain conditions as much as 120 to 125 pounds of sugar from sorghum cane may be fully met under favorable circumstances; but it would still remain to be demonstrated that this yield could be reasonably expected from year to year or even occasionally on a large scale. The subsequent experiments which are promised by Professor Stubbs at the Louisiana station will doubtless set at rest, in a few years, all these questions and demonstrate to the sugar-makers of Louisiana just what can be expected from sorghum as an adjunct to their great industry.

Experiments at Conway Springs.—In the reports of Messrs. Deming and Von Schweinitz, which follow, together with the analytical tables,* much interesting information may be found in regard to the sorghum-sugar industry in Kansas. The successful continuation of the work at Fort Scott has encouraged the belief in the possibility of a speedy establishment of a sorghum-sugar industry in Kansas on a large scale. The unfortunate financial outcome of the work, however, at Conway Springs shows that much is yet to be learned by those entering upon this industry before success can be confidently predicted. A discussion of the chemical data collected at Conway Springs will be found in connection with the analytical tables. It is

* See Bull. No. 20.

proper to say here, however, that the sorghum juices of the crop grown at Conway Springs show a higher content of sucrose than any large crop which has ever before been produced in the United States. This high content of sucrose, which appeared in the crop after the middle of September, as indicated by the analysis of the juices, was continued until the close of the working season in November. The samples of chips taken from the cells of the battery showed in their juices a high content of sucrose uniformly; much higher, in fact, than would be indicated by the output of sugar. One reason, doubtless, for this was the exceptionally dry season diminishing the content of water in the cane, and thus increasing the percentage of sucrose in the juice. This fact, though not established by the determination of the fiber in the cane, is plainly indicated by two other facts developed by the analytical work, viz, the diminished extraction when using the small mill of the same pressure as the season progressed and the high content of total solids in the juices. The output of sugar was evidently diminished by the character of the water used in diffusion; but that would be unable to account for the small yield of crystallizable sugar obtained with juices of the richness of those worked. Experiments made by boiling a solution of pure sugar with the water used in diffusion at Conway Springs proved that the presence of a large amount of gypsum did not tend to increase the inversion of sucrose; that it may, however, have interfered with the crystallization of the sucrose is a fact which can scarcely be denied. The actual output of sugar at Conway Springs in my opinion would have been considerably larger had pure water been employed in the diffusion battery; nevertheless the important fact remains that the yield of crystallizable sugar was wholly disproportional to the richness of the juices worked, showing that the high ratio of sucrose was not obtained at the expense of the solids not sugar in the juices. In other words, it appears that a cane whose juice is normal in quantity, say at about 90 per cent. of the total weight, and having a content of sugar equal to 10 per cent., with total solids at 16 per cent., will yield fully as much if not more sugar than a cane whose juice is abnormal, say not more than 80 per cent. of the total weight, with 12 per cent. of sucrose and 18 to 20 per cent. of total solids. Another important fact developed by a study of the data obtained at Conway Springs is in the persistence of the sugar content in the juice after the cane was fully ripened. In localities where considerable moisture may be expected in the soil as a result of frequent rains during the manufacturing season it has been noticed that there is a rapid deterioration of the juices beginning a short time after complete maturation. This has been especially noticed in the experience at the Rio Grande station. It has also been noticed by all careful observers of the sorghum grown in ordinary localities. The inspissation of the juices by the natural causes of an extremely dry climate appears to protect the sugar from this destruction. This is a point of the greatest interest to sorghum-growers, to whom the preservation of the sugar in the juice for a reasonable length of time is a matter of the greatest consideration. In the process of diffusion this thickening of the juice entails no loss, although if milling were used for expressing the juice the loss would be a most serious one. The above explanation of the character of the juice at Conway Springs is offered with some degree of hesitation, since I am fully aware of the danger of drawing conclusions in sorghum work from a too limited number of observations.

The manufacturing operations at Conway Springs were greatly hindered by faults in the machinery which could scarcely be avoided when the short time allowed for the manufacture and erection of the same is considered. Instead of taking three months for the erection of a sugar factory a whole year is none too long a time, and disaster, for at least one year, is certain to attend attempts to erect such machinery in the time allowed at Conway Springs.

What is needed now in the sorghum-sugar industry is the manufacture of sugar at a rate which will enable the manufacturer to compete with sugar from other parts of the world. A great step in this direction will be secured when the kind of machinery which has been pointed out by the investigations of the Department as necessary to success shall be constructed by skilled machinists and erected by skilled engineers with time enough at their disposal to finish their work before the manufacturing season begins. Some further remarks on this subject will be made in another place.

From a commercial point of view the results of the work at Conway Springs are wholly disappointing; to the person, however, who will take pains to inform himself in regard to the conditions which there obtained many points of encouragement will be found in spite of the financial failure of the first season's work.

Experiments at Douglass, Kans.—The practical experiments carried on at Douglass consisted in a thorough trial of the open system of diffusion (the Hughes system) to test its fitness for working on a large scale. For the details of the construction of the battery I refer to the report of Mr. Edson. In regard to its working in general I may say that it was a total failure both as to economy of power and success of extraction. The financial difficulties which were encountered by the company during the year were attributed largely to the use of this battery. The evaporating apparatus in use at Douglass was of first-class quality and arranged in a practical manner. The system of clarification tanks, double effects, and strike pan was as good as could be desired for sugar-making purposes. Had the company adopted the system of diffusion erected by the Department at Fort Scott there is every reason to believe that even during the first season it would have paid all expenses and made a reasonable profit. The attempt to introduce a new and untried system on a large scale shows the danger which too often besets the introduction of a new enterprise. The promoters of such an enterprise, not satisfied with what has been accomplished, attempt to follow new paths which often lead to unknown and unwished-for localities. It is best in any enterprise to accept what has been proved of value and not jeopardize the success of a commercial undertaking by introducing in its place a kind of experiment which, failing, would destroy all prospects of success. As will be seen by the analytical tables accompanying the Douglass report* the crop was of fair quality, showing about the average percentage of sucrose developed in Kansas during the last two or three years. The soil on which most of the crop was raised was somewhat richer in vegetable matter and contained less sand than the soil at Conway Springs. The climatic conditions of the two places were so nearly identical as to make apparently but little difference, yet it must be conceded that at Douglass the hot, dry winds produced less effect than at Conway Springs. There did not appear to be the same drying up of the juice, which may account to some extent for the per-

* See Bull. No. 20.

centage of sucrose therein being less. The agricultural results, however, were of the most encouraging nature, showing that in this locality a crop of sorghum cane can be grown which with proper treatment may be expected to yield from 80 to 90 pounds of sugar per ton of clean cane. Not only were the actual results rendered unfavorable by the kind of battery employed, but aside from this for some reason the centrifugals used proved to be wholly inadequate to the severe task imposed upon them. The drying of sorghum sugar is at best a difficult task and only the best approved centrifugal apparatus should ever be employed for this purpose. Had the battery at Douglass worked successfully much delay would have been experienced in the manufacture of the crop by the imperfections above noted in the centrifugal machines.

Experiments at Sterling, Kans.—At the very beginning of my connection with the experiments in the manufacture of sugar from sorghum I realized the importance of improving the quality of the cane to be used. In Bulletin No. 3, page 107, I made the following statements:

The future success of the industry depends on the following conditions, viz:

(1) A careful selection and improvement of the seed with a view of increasing the proportion of sucrose.
(2) A definition of geographical limits of successful culture and manufacture.
(3) A better method of purifying the juices.
(4) A more complete separation of the sugar from the canes.
(5) A more complete separation of the sugar from the molasses.
(6) A systematic utilization of the by-products.
(7) A careful nutrition and improvement of the soil.

Improvement by seed selection.—I am fully convinced that the Government should undertake the experiments which have in view the increase of the ratio of sucrose to the other substances in the juice. These experiments, to be valuable, must continue under proper scientific direction for a number of years. The cost will be so great that a private citizen will hardly be willing to undertake the expense.

The history of the improvement in the sugar beet should be sufficient to encourage all similar efforts with sorghum.

The original forage beet, from which the sugar beet has been developed, contained only 5 or 6 per cent. of sucrose. The sugar beet will now average 10 per cent.* of sucrose. It seems to me that a few years of careful selection may secure a similar improvement in sorghum.

It would be a long step toward the solution of the problem to secure a sorghum that would average, field with field, 12 per cent. sucrose and only 2 per cent. of other sugars, and with such cane the great difficulty would be to make sirup and not sugar. Those varieties and individuals of each variety of cane which show the best analytical results should be carefully selected for seed, and this selection continued until accidental variations become hereditary qualities in harmony with the well-known principles of descent.

If these experiments in selection could be made in different parts of the country, and especially the various agricultural stations and colleges, they would have additional value and force. In a country whose soil and climate are as diversified as in this, results obtained in one locality are not always reliable for another.

If some unity of action could in this way be established among those engaged in agricultural research much time and labor would be saved and more valuable results obtained.

In a summary of the methods which I have advocated for the improvement of the sorghum plant I said in an address before the National Sugar-Growers' Association, in Saint Louis, in February, 1887, that—

Finally our experiments have taught us that after all the mechanical difficulties which have been enumerated in the manufacture of sugar from sorghum have been overcome, the industry can not become commercially successful until the scientific

*In the six years which have passed since the above was written the sugar beet has been still further improved and will perhaps show 12 per cent. of sugar.

agronomist succeeds in producing a sorghum plant with a reasonably high and uniform content of sucrose and a minimum of other substances. This work is peculiarly the function of our agricultural experiment stations. In beet-sugar producing countries the production of the seed for planting is a distinct branch of the industry. So, too, it must be with sorghum. A careful scientific selection of the seeds of those plants showing the best sugar-producing qualities, their proper planting and cultivation, a wise choice of locality and soil, a proper appreciation of the best methods of culture, these are all factors which must be taken into consideration in the successful solution of the problem.

It was with this purpose in view that I made the arrangements with the Sterling Sirup Company by which the Department assumed control of the experiments which they had made in the cultivation of different varieties of sorghum. At the time this arrangement was made, viz, in the latter part of July, Mr. A. A. Denton was already in charge thereof for the Sterling Sirup Company, and he was appointed by you to continue in general charge under the direction of the Department. It was arranged with Mr. Denton that the general line of research should be such as is indicated in the above statements for the purpose in view. The chemists who were sent to take charge of the analytical work were instructed to co-operate with Mr. Denton in such a way as to secure favorable results and to make such suggestions as might seem valuable in the details of the work. Mr. Denton was requested to make a general study of the growth of the different varieties and of the habits of each one with reference to its fitness as a sugar plant. The most promising individuals of each variety were to be selected for experimental purposes and those showing the highest content of sucrose with the lowest content of other substances were to be preserved for future planting. The able manner in which Mr. Denton accomplished this work, assisted by the chemists of the Department, will be found in his detailed report. I regard it of the highest importance to the future success of the industry that the line of work thus commenced by the Department should be continued.

One great difficulty with which we have to contend is in the character of the appropriations made for the experimental work. I have called attention to this difficulty in former reports, and I wish to emphasize the matter here. The fiscal year in all Government affairs begins on the 1st of July. For investigations in agriculture no more unfortunate beginning of the year could be selected. On the 1st of July it is too late to commence experiments for that season; if these experiments be postponed until the next season arrangements can be made for their continuation only up to the 1st of next July, and thus they have to be stopped before they are well begun. The difficulty is extremely manifest in the present instance. The wisdom and value of continuing the experiments at Sterling last year will be denied by no one. Abundant funds are left over from the present year's appropriation to continue the experiments for another season. It is, however, unwise to make any arrangements for such work, since no part of it, except that which will be let out by contract, could be continued after the 1st of July, 1889. You thus find your hands tied, as it were, by the unfortunate disposition of the experimental year, which has to begin and end with the fiscal year. To avoid this difficulty, which has been one of the greatest causes of the disasters which have attended our experiments with sorghum, I earnestly recommend that all appropriations for field and manufacturing experiments in agricultural matters be made to take effect from the 1st of January each year instead of the 1st of July.

POINTS TO BE CONSIDERED IN BUILDING A FACTORY.

It is of the utmost importance, both for the individuals and the industry, that intending investors in the sugar business should carefully consider the problem presented to them in all its forms. Failure is not only a personal calamity but a public one, in that it deters capital from investment in an industry which, properly pursued, gives promise of a fair interest on the money invested.

Soil and climate.—The importance of soil and climate has already been discussed. In the light of present experience it must be conceded that a soil and climate similar to those of southern and western Kansas are best suited to the culture of sorghum for sugar-making purposes. Further investigations may show that Texas and Louisiana present equally as favorable conditions, but this yet awaits demonstration. Conditions approximately similar to those mentioned can doubtless be found in Arkansas, Tennessee, North Carolina, and other localities. The expectations which were entertained and positively advocated a few years ago of the establishment of a successful sorghum industry in the great maize fields of the country must now be definitely abandoned. He who would now advise the building of a sorghum-sugar factory in northern Illinois, Indiana, Iowa, or Wisconsin would either betray his ignorance or his malignity. A season of manufacture, reasonably certain for sixty days, is an essential condition to success in the manufacture of sorghum sugar. Early frosts falling on cane still immature, or a freezing temperature on ripe cane followed by warm weather are alike fatal to a favorable issue of the attempt to make sugar. Sober and careful men will not be misled by the claims of the enthusiast, by the making of a few thousand pounds of sugar in Minnesota, by the graining of whole barrels of molasses in Iowa. Four or five million acres of land will produce all the sugar this country can consume for many years, and these acres should be located where the climatic conditions are most favorable. During the past season sorghum cane matured as far north as Topeka, but in 1886 the cane crop at Fort Scott was ruined by a heavy frost on the 29th of September and in 1885 a like misfortune happened at Ottawa, Kans., on the 4th of October. These interesting facts show that these points are on the extreme northern limits of safety for sorghum-sugar making, and the region of success will be found to the south and west of them.

Natural fertility of soil must also be considered as well as favorable climate. The sandy pine lands of North Carolina can not hope to compete with the rich prairies of southwestern Kansas and the Indian Territory. Indeed, in my opinion, the last-named locality, should it ever be opened to white settlers, is destined to be the great center of the sorghum-sugar industry. Nevertheless, those who plant the virgin soils of this great Southwestern empire must remember that to always take and never give will tire the most patient soils, and a just return should be annually made to the willing fields. A judicious fertilization, rotation, and rest will not only preserve the natural fertility of the fields, but give even a richer return in the improved quality of the cane and the greater tonnage secured. Perhaps the most sensible solution of the problem of the disposition of the waste chips will be found in returning them to the soil. These chips have a positive manurial value in the nitrogen they contain, while their merely physical effect on the soil may prove of the highest importance.

Water supply.—The misfortunes which have attended many attempts in the manufacture of sugar by diffusion, by reason of an imperfect or insufficient water supply, are a sufficient warning on this subject to the careful student. Not only should the water supply be abundant and easily accessible, but the portion of it at least which is to be used in the battery should be as pure as possible. The presence of carbonate of lime and other carbonates in water is not injurious, but the evil effects of a large amount of other kinds of mineral matter are shown in the data from Conway Springs. When the supply of water is insufficient it has been customary to use ponds for receiving the waste from the factory, so that it may be used again. This method is applicable, if care be taken to prevent organic matters, scums, etc., from entering the water supply. In case this precaution is not taken the operator of the factory may find himself in the condition in which the Department was placed in its first experiments at Ottawa and Fort Scott, in being compelled to use water foul and putrescent. It is scarcely safe to rely upon a well for a supply of water, especially if it have to be sunk to any depth. Where pumping machinery must be placed many feet below the surface, as in the cramped condition which attends its erection in a well, serious difficulties may arise from the machinery getting out of order, and a great loss of energy may ensue from the necessity of lifting the water to a great height. In all cases where it is possible a running stream of water should be selected for the supply and the factory should be placed conveniently near its banks. The importance of this matter is emphasized the more when it is considered that the most favorable localities for sugar making, as indicated by the present state of our knowledge, are situated in regions where the water supply is notably deficient; yet it must be admitted that even in southern and western Kansas it will not be difficult to find localities for the erection of sugar factories where the water supply is certain and abundant. In the light of past experience it is not probable that any further mistakes will be made in this direction. Careful estimates should be made of the quantity of water required and absolute certainty should be secured of the supply of that amount of water and even of a much greater amount in cases of emergency. The only safety will be found in some such plan as this.

Proximity of cane-fields.—Another point which must be taken into consideration in the location of a factory is the distance which the cane is to be transported. This is a matter which of course the farmers raising the cane are more interested in than the proprietors of the factory, when the cane is grown by contract. With good roads, in a level country, it is easy to draw from 1½ to 2 tons of field cane at each load. The average price which is paid for such cane at the present time is $2 per ton. It is evident that at a given distance, varying according to the price of teams and labor in each locality, the cost of transportation would equal the total receipts for the cane; in this case the farmer would have nothing left to pay for the raising of the cane and profit. Evidently true economy, from an agricultural point of view, would require the cane to be grown as near the factory as possible. It would be well, indeed, if all the cane could be grown within a radius of a mile from the factory. This would give, in round numbers, 2,000 acres tributary to a factory. With an ordinary season this ought to produce 20,000 tons of cane. The lengthening of the radius of this circle by one-half mile would give the greatest distance to be hauled 1½ miles, thus vastly increasing

the surface tributary to the central factory. It is true that at the present time farmers are easily found who are willing to draw their cane 4, 5, and even 6 miles, but this condition of affairs can not be continued when the business is fully established and the factories in sharp competition with each other. In case the exhausted chips are to be returned to the soil as fertilizer the importance of a centrally located factory as described is doubly emphasized.

Fuel.—A cheap and abundant supply of fuel is not less important than the raw material to be manufactured into sugar. As far as the sorghum-sugar industry is concerned the coal which is used for fuel is transported almost exclusively by rail. In locating a factory, therefore, both for convenience of shipping the product and for receiving a supply of fuel, it should be placed sufficiently near a railway line to enable it to be connected therewith by a switch. It is better, however, that the switch should be of some considerable length than that the water supply should be remote or the cane in distant fields.

The problem of burning the exhausted chips has not yet been successfully solved and I doubt very much whether it will be.* Save the softening which the chips undergo in the process of diffusion the difficulty of expressing the water from them is as great as that of expressing the juice from fresh chips. Thus to dry the chips sufficiently to make them economical for fuel would require a vast expenditure of power which would hardly be supplied by the increased supply of steam generated by their combustion. Experiments during the season of 1887–'88 at Magnolia plantation, Louisiana, showed that an ordinary cane-mill was poorly adapted to the pressure of exhausted cane chips. The feeding of the mill was difficult and the amount of fuel produced seemed wholly disproportional to the expense of preparing it. It has been proposed to try the process used for extracting the water from beet pulp for the purpose of drying sorghum chips. There is nothing whatever in the experience of the beet-sugar factories to warrant the belief that such a process would render the chips sufficiently dry to burn. Although I would not be considered as discouraging any further attempts in the direction of preparing sorghum chips for fuel, I must be allowed to express the belief that for some time to come coal must be relied upon solely for this purpose.

If the chips are to be successfully burned in the future, we may make up our mind that it will have to be done by previous pressure in mills which in all their appointments shall be as strong and efficient as those which have been in use for expressing the juice from cane. It can not be hoped that these chips will be made sufficiently dry by exposing them to the sun, and in artificial desiccation the amount of fuel required would be almost as great as that used in the evaporation of the original juice. It is claimed that at Wonopringo, in Java, as reported in the *New Orleans Item* of December 16, 1888, the Fives-Lille Company has succeeded in drying the chips by passing them through two powerful three-roll mills; and that the chips thus dried do not contain more than 55 per cent. of moisture and burn readily in an automatic furnace invented by Godillot. If it be assumed that 100 pounds of chips contain 10 pounds of combustible matter it is seen that nearly 80 pounds of water will have to be expressed therefrom before they are fit for fuel. I am doubtful

***Experiments made since the above was written seem more favorable to the successful burning of the chips.**

whether such a process will prove profitable save in countries where fuel is very dear as it is in Java and Cuba.

Cost of factory.—It is an almost universal experience that the actual cost of a sugar factory is underestimated by those who undertake its erection. Many of the disasters which have attended the manufacture of sorghum sugar have been due to a miscalculation of the cost of the apparatus necessary for the purpose. It is the part of wisdom to avoid mistakes of this kind, and before undertaking the erection of a factory to fully understand the amount of outlay which will be required. The cost of a factory will of course vary according to its capacity and the character of the machinery and building erected. In my opinion there is little economy in using cheap machinery, hastily and poorly put together. Success is more likely to be obtained by using the very best machinery which has been devised for sugar-making purposes, and erecting it in a lasting and substantial manner. The economy which is secured in operating such machinery far exceeds that which would be obtained by erecting a cheaper plant. The character of the plant must also be taken into consideration; it should be sufficiently large to allow a proper distribution of all parts of the machinery without crowding, and sufficiently strong to afford a proper support for such portions thereof as may rest upon it. Due regard should also be paid to risks of fire, and that portion of the factory especially exposed to such dangers should be made as nearly as possible fire-proof. The plans and specifications for all the machinery should be carefully prepared under the direction of a competent engineer and architect, and the machinery furnished by manufacturing firms whose experience and reputation are a guaranty of the excellence of their work. For a complete factory capable of working 200 tons per day the cost may be estimated at $60,000 for a minimum and $100,000 for a maximum, the difference being caused by the elaborateness of the work. This may seem a large sum, but it is highly important that intending investors should know the magnitude of the undertaking which they propose. An estimate which exceeds the actual outlay by $10,000 will be far more satisfactory to all parties concerned than one which falls short of it by the same amount.

Technical and chemical control.—The manufacture of sugar from sorghum is no mysterious process known only to one or two persons as attempts have been made to establish; nevertheless, it must be understood that without experience in the manufacture of sugar the most competent engineer may fail. It is best, therefore, that intending investors understand this beforehand that they may be able to secure some one to take charge of the manufacture of sugar who thoroughly understands the needs of the business and has had some experience in the conduct thereof. Perhaps there are not more than fifteen or twenty such men now in the United States, but their number will be largely increased within a short time. It would seem, therefore, that the number of factories which could be successfully operated in the next year or two is limited, and this fact should be taken into careful consideration by those intending to invest money in the business. An intelligent young man of good education, with quick perceptions and of industrious habits, would be able in one year, with a sorghum-sugar factory, to obtain a knowledge which would enable him to take charge of a factory with some degree of success on his own responsibility. One object which the Department has had in view in its experiments has been in having them open not only to public inspection but to careful technical study to

such persons as chose to make the attempt. It is to be regretted that at least one company, who, through the courtesy of the Commissioner of Agriculture, was permitted to use a large amount of machinery belonging to the Department, have so far forgotten their obligations to the public as to refuse permission for a technical study and report on their operations during the past year. Public property is devoted to a poor purpose when used in such a manner.

The importance of chemical control of the manufacturing work is so evident that I need not dwell upon it long. The vagaries of the sorghum plant are so pronounced as to require the careful supervision of the chemist at all times. In localities not far removed differences in the character of the sorghum are most marked, as illustrated by the data obtained at Conway Springs and Douglass, Kans., during the past year. To determine the fitness of the cane for the manufacture of sugar, control the workings of the factory, and find and remove the sources of loss in the sugar-house are duties which can be committed only to the chemist. For many years at least this chemical supervision will be necessary and its utility will always continue.

PROGRESS OF DIFFUSION WITH SUGAR CANE.

Two plantations are using the process of diffusion during the present season for the extraction of sugar from sugar cane. These are "Sugar Land" plantation of Colonel Cunningham in Texas, and the Magnolia plantation of Governor Warmoth in Louisiana. The latest reports from the "Sugar Land" plantation I found in the *Item* of December 15, 1888. At that time it is reported that over 2,000,000 pounds of sugar had been made and the diffusion battery was working up from 300 to 350 tons of cane a day. It is also reported that an average of 194 pounds of sugar is made per ton. From the analyses of the cane reported in the *Item* of November 28, 1888, it appears that the juice has about 12 per cent. of crystallizable sugar. The success of the operation seems to be fully assured.

The working of the battery at Magnolia is also satisfactory. The analysis of the cane shows that it is extremely rich in sugar. In the *Item* of December 4, it is reported that the juice contained 13.7 to 16.6 per cent. of sugar. A polarization had been made showing as high as 19.2 per cent.

Under date of December 9, Mr. G. L. Spencer writes as follows:

Diffusion is working to every one's satisfaction. We have had a great many delays, almost all of which were caused by the Yaryan quadruple-effect pan. Governor Warmoth had the apparatus overhauled this morning and found that the exhaust pipe from the pump opens into the second effect, making a pressure pan of this when working with more than 3 or 4 pounds of steam. This defect has been remedied and we hope everything will be all right now. The cutter gave a great deal of trouble at first, so much that we thought it would be necessary to abandon it. Finally two holes cut in the side of the casting opposite the cutting disk relieved it, so now it is working well. We can cut a cell of chips averaging 2,864 pounds in seven and one-half minutes. The dilution will probably surprise you. I intended starting with a dilution of 33 per cent., but by a mistake in measurement I started with 50 per cent. With 50 per cent. dilution we left from .28 to .70 per cent. sucrose in the chip juice. I gradually reduced the dilution until it dropped to 14.8 per cent., leaving about .70 to 1 per cent. of sucrose in the exhausted chip juices. We have finally commenced running with a dilution of 21 per cent., leaving .42 per cent. of sucrose in the exhausted chip juices. With pulped cane, such as Hughes's apparatus gives, I would be willing to guaranty a dilution of only 18 per cent. and to leave less than .50 per cent. of sugar in the exhausted chips. We tried the use of lime in the cells. Practically when making white sugar we can not work the battery hot enough to obtain clean juice. We try to keep the battery at about 90° C.

Further experiments have also been in the application of diffusion to sugar cane by Prof. W. C. Stubbs at the Kenner sugar experiment station. A full report of this work will be published in a forthcoming bulletin of that station. In the *Louisiana Planter and Sugar Manufacturer* of December 1, 1888, a report is found on a part of the work done. As high as 240 pounds of sugar have been obtained per ton of cane. The results of the work are in every way encouraging.

From the above it is seen that diffusion with sugar cane is an assured success and we may expect to see it gradually displacing the milling process throughout the sugar-producing world.

The use of lime in the diffusion battery.—The use of carbonate of lime in the diffusion battery and the patent obtained for this process by Prof. Magnus Swenson are fully discussed in Bulletin No. 17, pp. 61 *et seq.*

Since the publication of this bulletin and Bulletin No. 14, further experiments at Conway Springs have demonstrated that the method originally proposed by me for the use of lime to prevent inversion in the battery by evenly distributing finely divided lime upon the fresh chips has proved satisfactory. An apparatus constructed by Mr. E. W. Deming succeeded fairly well in evenly distributing over all the chips entering the cell the lime in such fine state of division as to prevent any portion of the contents of the cell from becoming alkaline. The lime was prepared by air slaking and sifting through a fine sieve into a barrel covered by a cloth to protect the laborer.

During the past year the use of lime in the diffusion battery for clarifying the juices has received a good deal of attention. The first person who proposed this process and took out a patent upon it was Mr. O. B. Jennings. Letters patent No. 287544, dated October 30, 1883, were issued to Mr. Jennings on an application filed on the 2d of April, 1883. Following is an abstract of Mr. Jennings's patent:

Be it known that I, Orlando B. Jennings, of Honey Creek, in the county of Walworth and State of Wisconsin, have invented certain new and useful improvements in the manufacture of sugar from sugar-cane, sorghum, maize, and other plants of which the following is a full, clear, and exact description:

This invention relates to the manufacture of sugar from different sugar-producing plants, including sugar-cane, maple, sorghum, and maize; but it has more especial reference to defecating the juice in the stalks of sugar-cane, sorghum, and maize and extracting the juice from the residue or bagasse for subsequent boiling into sugar and sirup.

In making sugar from sugar-producing plants with my invention, it is my purpose to extract and utilize all of the saccharine juice and to obtain entire control of its defecation, so as to make a sirup free from foreign matter and elements of fermentation. By it the juice in evaporating is free from skimmings or precipitates that are always liberated in the ordinary method of extracting, which waste my invention avoids.

Applied to the manufacture of sugar from cane and other stalks the invention consists in a process of preparing said stalks for the more perfect extraction of the juice by reducing the same to a finely-comminuted or dust-like condition, and whereby the juice cells are thoroughly crushed and ruptured. This part of the invention also includes a combination of circular saws, forming a compound saw, for reducing the canes or stalks to such finely-comminuted condition, likewise sprinkling or mixing with said dust, before defecation, dry lime or lime whitewash in powder. Such lime combines with the acid in the dust, and upon suitable application of heat to the whole forms double precipitation at one and the same time.

Furthermore, the invention consists in a process of precipitating the matter in the cane-juice cells and cane pulp, or in the juice of any sugar-producing plant, however obtained, by exposing the juice or material under treatment to a temperature of over 212° Fahr., and subsequently removing the juice from the woody or precipitated matter by washing the same with currents of water. In carrying out

this part of the invention I use a cylinder or other suitable vessel in which the temperature is raised to the required degree (about 212° Fahr.) for defecation and precipitation of the matter capable of being precipitated, whether the same be contained in sugar-cane, sorghum, and maize stalks, reduced to dust or not, or in any saccharine juice, including maple sap, the temperature varying from 228° to 267° Fahr., according to the ripeness of the material under treatment and other conditions. This vessel is suitably constructed or provided with means to admit of the introduction of the material to be treated; also, to provide for the forcing out of the exhausted bagasse or refuse, and for the introduction of steam while and after charging it; likewise, steam to act upon the condensed water and released juice and force them out through a filter. Means are also provided for running the wash water from a series of tanks in succession through said vessel, to act upon the charge therein, and an arrangement of defecating-tank connections for introducing scum, sediment, and sweet wash-water upon a succeeding charge.

In the process of extracting the saccharine matter of cane, the mixing with the comminuted cane, before the passage of the same into the diffusing apparatus and the defecating of the same, of dry lime or lime whitewash, whereby the material will be thoroughly defecated without the liability of the admixture therewith of the precipitate of the lime, substantially as described.

The combination, with the diffusing tank of one or more defecating tanks to which the juice is delivered from the diffusing tank, and pipes provided with valves for drawing the skimmings, settlings, and sweet water from said defecating tank or tanks and passing the same into the diffusing tank or vessel, essentially as and for the purposes herein set forth.

In combination with the defecating tank, diffusing tank, and a suitable evaporator, the settling tank provided with a discharge pipe for running the juice into evaporator, and with means for passing its sediment into the diffusing tank, substantially as described.

It is seen that Mr. Jennings makes a broad claim for the application of the process of clarification in the diffusion apparatus for all sugar-producing plants. Mr. Jennings has claimed that the process devised by the Department for the use of lime to prevent inversion in the battery is an infringement on his method. Any one who will carefully examine Mr. Jennings's claim, as set forth by himself in his application for a patent, will see that the two processes are entirely different not only in principle but in the method of application.

In a letter to the *Rural World*, published on the 13th of December, 1888, I endeavor to make this matter clear. Following is a copy of the letter:

WASHINGTON, D. C., *December* 1, 1888.

Editor Rural World:

I have read in the *Rural World* of the 22d of November the letter from O. B. Jennings, of Grover, Colo., in regard to his patent for clarifying cane juices in the diffusion battery.

Mr. Jennings is laboring under the mistake that I have been using his process and spending five years on what he showed me how to do at first. This is a complete misapprehension of the case. I have never denied to Mr. Jennings the honor of inventing the method of clarifying cane juices in the diffusion battery; in fact, long before his letter in your paper appeared I wrote a note to the *New Orleans City Item*, specifically claiming for him the honor of the invention which had been attributed to another source.

It is important to sugar-makers, either present or prospective, to know the following points, viz:

(1) The process of using carbonate of lime in the diffusion battery is a patented process which can only be used under royalty or by permission of the inventor, Professor Swenson.

(2) The process of clarifying the cane juices in the diffusion battery is a patented process and can only be employed under royalty or by permission of the inventor, Mr. O. B. Jennings, of Grover, Colo.

(3) The use of dry lime or lime in any form in the diffusion battery to prevent inversion is a process devised by the Department of Agriculture and offered free to all sugar-growers in this country. Under proper chemical control it is more efficient than the use of carbonate of lime.

I will say further that I have never tried in any way to use Mr. Jennings's process, since in an ordinary diffusion battery it would be wholly impossible to do so. The high temperature which he requires for the proper clarification of the juices would render the circulation of the liquid in the battery almost impossible.

Respectfully,

H. W. WILEY,
Chemist.

The process of using lime in the diffusion battery for clarifying purposes it is claimed has been successfully practiced in Java and Australia.

Prof. W. C. Stubbs has also used it with success at the sugar experiment station at Kenner, La.

Col. E. H. Cunningham, of Sartartia, Tex., has also used the process with success, as indicated by the following letter from him published in the *Louisiana Planter* of December 1, 1888:

My diffusion battery is now working nicely, and I am very much gratified at the results obtained. Diffusion is a success beyond a doubt. I am now working sugars by running the juice direct from the diffusion cells to the double effects without any clarification, except using a little lime in the diffusion cells.

I shall be glad to have a visit from you or any of your friends who feel an interest in diffusion.

The process of ordinary clarification in my opinion is more favorable to the production of a pure sugar than any form of clarification in the cells of the battery. The process as practiced at Kenner and Sugar Lands, however, differs from that described by Mr. Jennings in working at a lower temperature.

COMPARISONS OF TOTAL SOLIDS DETERMINED BY SACCHAROMETER AND DIRECT DRYING.

During the season of 1887 I instructed the chemists at the Fort Scott station to make a series of comparisons between the total solids as determined by our standard saccharometer and by direct weighing. The desiccations were to be made in flat dishes partly filled with loose asbestos or clean sand. The purity coefficient of the juice as shown by the spindles appeared too low to permit so large a yield of dry sugar. As was expected, the total solids as determined by direct weighing were found considerably less than were indicated by the spindles. The ratio of each variation was not the same, but a large number of determinations established a mean rate of variation which will make it possible to approximately correct the reading of the common spindle. At Magnolia last year similar experiments were made with the juices of the sugar cane, but these were not extensive enough to fix the rate of variation for those juices. Following is a record of some of the work done here:

Comparison of total solids.

No.	Total solids by spindle.	Total solids dried in dish.	Difference.	Total solids in hydrogen.	Difference.
	Per cent.	*Per cent.*		*Per cent.*	
6029	12.60	11.93	.67	....	....
6065	15.20	13.54	.66	....	....
6070	13.20	12.87	.33	....	....
6074	12.20	11.48	.72	10.94	1.26
6075	11.50	11.04	.46	10.84	.70
6076	13.30	12.85	.45	....	....
6079	12.30	11.77	.53	11.59	.71
6081	12.50	12.00	.50	11.65	.85
6083	16.30	16.04	.26	....	....

The determinations in hydrogen were made in a specially constructed apparatus consisting of a glass cylinder furnished with a glass stopper carrying two tubes with stop-cocks for displacing the air with an atmosphere of hydrogen. The juice was absorbed by a dried-paper coil and supported in the cylinder on a disk of wire gauze resting on a lead tripod. The cylinder contained 25 c. c. of strong sulphuric acid. The cylinder carrying the coil was placed in a steam bath filled with dried hydrogen at 100°. The stop-cocks were then closed and the whole apparatus left at the temperature of the steam for five hours. The sulphuric acid absorbed all the moisture, and after cooling and filling the cylinder with dried air the coil was removed and weighed in a closed holder.

The determinations in flat dishes were made by drying 2.5 to 3 grams of the juice at 102° for five hours. Scarcely any difference was noticed between the results given by the plain dishes and those filled with sand or asbestos, except in the work at Conway Springs.

In the determinations made here in plain dishes the percentage of total solids was 4.68 per cent. less than by the spindle. In the determinations in hydrogen they were 6.94 per cent. less. The determinations in hydrogen, therefore, will show 2.26 per cent. less total solids, calculated on the number given by the spindle, than those obtained by drying.

At Douglass, Kans., the normal juice, calculated on the data furnished by the spindle, showed a loss of 8.61 per cent. in total solids when dried in open dishes.

At Conway Springs this loss in plain dishes was 7.24 per cent., and in asbestos 8.23 per cent.

With diffusion juices these losses were for Douglass, 11.34 per cent., and for Conway Springs, 9.67 per cent. in plain dishes and 10.83 per cent. in asbestos.

The mean loss for normal juices at Douglass and Conway Springs was 8.36 per cent.

For the diffusion juices the mean loss was 10.61 per cent.

It appears, therefore, that a saccharometer of the standard Brix variety as standardized by pure cane-sugar solution must be corrected by fully 10 per cent. of its readings in order to give an approximately true indication of the total solids found in the diffusion juice of Kansas sorghum. For sorghum grown in New Jersey, which was the source of most of the juices examined here, the correction will be only about 7 per cent.

I am having constructed some saccharometers with scale to read as indicated by the above corrections.

The apparent purities of the sorghum juices will be considerably raised by this correction. Thus at Douglass the purity of the normal juice is raised from 59.63 per cent. to 65.31 per cent., and at Conway Springs from 66.70 to 72.76 per cent. The purity of the diffusion juices of the two localities is raised from 58.59 to 66.86 per cent. and 62.92 to 71.13 per cent., respectively.

SUMMARY.

It has been my duty during the past few years to report the facts concerning the sorghum industry as they were developed by the researches of the Department and of others. These facts have been of a varied nature; sometimes they have been favorable to the industry and sometimes unfavorable, but in all cases they have been fully set

forth and commented on in the light of the knowledge at hand. In these investigations I have been unmoved by the abuse of interested parties which I have received on account of my unwillingness to conceal the weak points of sorghum. It was thought when Bulletin No. 18 was issued that the experimental work on the part of the Department with sorghum was finished, and in that bulletin a summary was made of the investigations conducted in the United States during the past twenty-five years. In that bulletin I expressed the belief that with cane as rich as had been produced in Kansas on a large scale it was probable that a yield of from 80 to 90 pounds of sugar per ton of clean cane can be secured. The results of the past year confirm me in this opinion, and indicate that with wise management and careful control, and proper selection of locality, the sorghum-sugar industry may be financially successful. In previous pages I have endeavored to set forth carefully some of the things which must be considered in order to secure the above result; but it must be remembered that my individual opinion is simply based upon the study of the facts which have been set forth. These data are accessible to every one who cares to make a careful study of the subject, and therefore each one interested has every opportunity to form his own opinion concerning the matter. Since it is my business to investigate rather than to theorize I have contented myself chiefly with reporting facts rather than expounding theories.

ABSTRACT FROM REPORT OF H. A. HUGHES.

RIO GRANDE, N. J.

The whole season of this year has been devoted entirely to experimental work, with the object of securing additional light on crop-growing, manufacturing, and commercial problems.

The past season was the end of a series of crop-growing, covering a period of nine years, and fully confirmed the fact that the safe time for planting Orange cane, after allowing for variations of climate, had passed.

Analyses.

Description.	Sucrose.	Brix.	Purity.
	Per cent.	°	
Amber	7.35	13.70	53.60
Kansas Orange	8.47	14.21	59.60
Late Orange	6.74	12.01	52.80

The limit of crystallization can be marked at 55 per cent. purity. Crystals can be formed below this degree, but they are difficult to separate in the centrifugals.

The Late Orange was mostly below the crystallization point, and although crystals were attempted by the sugar-maker, in order to find out the limit at which graining takes place, and several pans were actually grained, the grains were so small that conclusions were reached adverse to the boiling for sugar of such material.

The following deductions are made from the analysis of more than 38,000 tons of cane, and cover a period of nine years. This table will be found convenient for reference, under the heading of season 1880 to 1888, inclusive. It must be borne in mind that these facts will only strictly apply to this climate and this soil; but until it can be proved that they will not apply elsewhere, it will serve as a guide, and should be interpreted by taking into consideration the fertilizers used, the variations of the seasons, and the nature of the plant.

SEASON 1880.

Ripening of the cane was traced with the polariscope, and when 14 per cent. of sugar was reached cutting began; and during the short time required to harvest it

no damage was received from winds or frosts. The juice was reduced to semi-sirup in an open evaporator, and three weeks later was shipped to Philadelphia and worked for sugar, marking firsts, seconds, and thirds. The cane was planted in hills 4 feet apart, and sufficient plant food used.

The impression made by this crop was that rich cane could easily be grown on poor land, and that with a little more fertilizing large crops could be made. It has since been found by long and costly experiment that all the conditions for Amber cane were most favorable excepting that a large tonnage could only have been secured by proportionately fertilizing.

SEASON 1881.

Farmers raised the entire crop. The acreage was not known. It was proved this year that with seed from the same lot some farmers grew cane 14 per cent. of sugar in the juice, while others grew it with only 6 per cent. Many conjectures were made, and the impression prevailed that some lands were suitable for cane and others unsuitable. It was, however, apparent that all who had the best reputations for farming raised the highest testing canes.

SEASON 1882.

Cane was grown by the company. Pacific guano high in nitrogen was used, and only Amber cane was planted. The Late Orange cane was grown only in sufficient quantity to supply seed for the next year. The nitrogen had the effect to keep the cane leaves green for a long time, and even after frosts the cane remained in good condition, and was on November 4 higher in sugar than on September 4. Since we have had less nitrogenous fertilizing and more of other plant food this variety had steadily fallen in test, and the period during which it retains its highest sugar content has been shortened. It is not safe to depend on this variety of cane for the whole season even if nitrogen is used largely with other plant food, because of its tendency to lodge and break with high winds.

SEASON 1883.

Yard composts and begasse were used in such small quantities that the nitrogen did not stand out prominently. The Amber had gone by its season before October 8, and had not the Late Orange been substituted this season for sugar-making would have ended on that day instead of November 14, when the crop was all in.

SEASON 1884.

Stable manure in large quantities, also a dressing of dissolved bone ash from South America, rich only in phosphoric acid, was used.

The phosphoric acid ripened the cane fully two weeks earlier than usual, and although the leaves were dry the Amber cane held its sugar content without loss, until worked up on October 11. The Late Orange was affected in the same manner, according to its season; and although apparently dried up too, still held its sugar.

Mill-juice tanks containing 6,000 gallons were quite common, testing 13 to 13½ per cent. of cane sugar from October 11 to October 29, after which time there was a gradual falling off, until November 11, when the tanks stood 12 per cent. and 77 purity; this ended this season, as the crop was worked up.

The small experimental plots conducted by the State experiment station have always showed that, by doubling the dose of phosphoric acid, the cane sugar falls off seriously; but as it is my intention to deal only with cane in immense masses as found at the sugar-house, I merely call attention to this fact.

This year produced nearly 400,000 pounds of merchantable sugar, and there was found, by adding the sugar in the molasses and the loss in the begasse as it came from the mill, that over 1,500,000 pounds of sugar were in the crop.

Molasses only was made from the begasse this season, diffusion being for the first time applied.

SEASON 1885.

No phosphates were used, and there was not enough compost to properly furnish nitrogen to the crop; still, the nitrogen was felt, and when the season commenced on September 2, the cane was so green we at one time thought it would be better to stop work.

When work was begun the Amber cane contained 5.04 per cent. of cane sugar and increased to 8.8 per cent. on September 29, when the variety was all brought in. The Late Orange cane contained 10 per cent. of sugar when first cut, and gradually raised to 12.57 per cent., slowly declining to 10 per cent. by November 11, the end of the season. This crop was planted practically at the same time as the crop of 1884, and harvested at the same time. Had a large quantity of nitrogenous fertilizing been used the sugar contents would have been much higher. Small quantities of nitrogen on lands deficient in organic matter will make poor crops. This was our experience again and again, and to secure immense crops high in sugar, potash should be combined with nitrogen.

SEASON 1886.

Small quantities of nitrogenous fertilizing and light dressings of muriate of potash were used. The crop suffered severely for lack of food. During the season, where plenty of nourishment had been supplied, the crop came to the standard. When this was not the case, the Amber seed remained in a milky state for a long time and soured as it stood in the field, after three days of abnormally hot weather, making the cane unfit for sugar-making. The Late Orange suffered from lack of nitrogenous fertilizing, and the sugar test rose and fell in proportion as this food and potash were present; but, being a longer feeder, it did not suffer throughout the season so much as the Amber.

The Kansas Orange was introduced this year, and being a stranger, the ground was properly selected and composts and potash applied in sufficient quantities, a 12 per cent. cane, with purities over 70°, being its record. The record of the Late Orange cane for the balance of the season is high and low test, according to the land, finally ending with the crop all harvested with a test of 9.45 per cent. This crop discouraged the sugar company notwithstanding the gains by diffusion, which process had been introduced in 1884. Local agriculturists pronounced the verdict that the lands being exhausted by continual cropping were ruined and unfit for crop of any kind. The plantation was then sown in clover; no fertilizing was done. The farmers laughed at the notion that land unable to grow large cane crop could be expected to grow grass; but it did, and the clover crop on these lands has been unprecedented and are the envy and wonder of local farmers, and judging the land from the farmers' own stand-point, it is to-day in better condition than ever before. The clover had found the missing nitrogen and furnished organic matter.

A lot of land on these farms grew poor cane for years, and in 1887, instead of planting it with clover, composts and potash were supplied and cane planted; by planting the ground with twice the number of hills to the acre, portions of the land approximated 28 tons of cane to the acre.

SEASON 1887.

The cane was planted from May 9 to June 3, and the late varieties failed to mature properly. A good dressing of begasse, yard compost, and potash was used. The crop was doubled by planting 3 feet by 24 inches; purity ran about 64° and tests were good. The Late Orange cane ripened sufficiently to retain its sugar in crystallizing quantities, through frost and ice, until December 5. Particulars of this season can be found in Bulletins No. 17 and 18 of the Agricultural Department, and in reports of the New Jersey Experiment Station. A small plot was fertilized with large quantities of nitrogenous manure and planted with Amber seed grown in 1886, from which no cane sugar could be made. The cane was tested on September 7, 1887, and was found to test 13.35 per cent. cane sugar; Brix, 17.21°; purity, 78; and it remained a long time after in fine condition. The same day milled chips from a field planted from the same lot of seed and fertilized with potash and phosphoric acid, polarized 8.88 per cent., and had a purity of 63.61.

SEASON 1888.

Only complete fertilizers were used on one field, and muriate of potash was spread on another field that was poor and had never been in cane. The hills were 3 feet by 24 inches.

Amber cane was planted on May 18 and Kansas Orange and Late Orange from May 19 to June 10. A cold, wet June followed, and the result was unripe cane. The crop was taken off between September 23 and November 1. The Amber cane was very poor in sugar. The Kansas Orange ran from 9.58° to 8.25°. The stand on one field of Orange (Kansas) was preserved intact from cut and wire worms by patches of volunteer canes where seed had been stacked previously, and some seed had been left on the ground. The worms gathered where plants were the thickest,

leaving the hills almost unmolested. When the ravages are feared, seed could be sprinkled down the center of the rows, and afterwards be destroyed by the cultivator without extra expense. They only destroy while the plants are very small and disappear with the return of dry, hot weather.

The Late Orange tested from 6.94 to 6.54 per cent. Scarcely any seed on this variety was ripe, and in a great many of the plumes seed was not formed, neither had the cane power to resist ice and frost. These facts prove conclusively that the safe time for planting Late Orange had been passed. It is possibly true this variety might have been very rich in sugar with a late fall and hot weather during June and September; but this risk is not a safe one, and as it positively can be avoided by earlier planting it should be done.

OBSERVATIONS.

The time for planting cane in this climate is, for Early Amber, not later than May 20; Kansas Orange, not later than May 10; Late Grange, not later than May 1. Ten days earlier can safely be risked.

Nitrogen prolongs the vitality in cane. Nitrogenous fertilizers combined with potash is the best combination for large crops and high-testing juice. Phosphoric acid hastens the ripening of the cane about two weeks, and too much phosphoric acid reduces the quantity of sugar in the juice.

Potash makes large and strong stalks. If canes are desired to be worked after frost and ice they must be supplied with ample food, be well grown, and of a late variety. If canes are not well advanced when frosts and ice strike them they will not be able to hold the cane sugar long. The earlier the variety the later it should be planted. If canes increase rapidly in cane sugar soon after frosts strike them they will soon be worthless for sugar-making. If they do not increase at all, or very little, they will remain good for a long time, providing the frost was severe, long enough to kill, or almost kill, the leaves. The Amber has less power to resist frost and ice than Kansas Orange, and the Kansas Orange less than the Late Orange.

The time which the sugar remains in high percentage in the cane is largely under the control of the cultivator. In all attempts to improve the seed by selection and increase the sugar and purity, the cultivation must be taken into consideration. High-testing seed will make poor-testing canes if plant food is not present in sufficient quantities or if the cultivation is neglected. Poor-testing seed will give high-testing canes if the seed is of a good variety, and ample food has been supplied, with good cultivation.

Canes can not be grown, rich in sugar, by starving them. Ground well supplied with plant food and badly cultivated will give very small canes, rich in sugar. That there are other peculiarities in other varieties is shown plainly in the case of the White African. Although planted late last spring, and the ground fertilized precisely like the Amber and Kansas Orange, it contained this year 12.30 per cent. cane sugar, purity 69°, on September 27, time the field was out.

The seed was given to the writer by Dr. Collier along with sixty-eight other varieties in 1883, all of which were planted, but for certain good reasons this cane was the only one selected from the lot. It has been grown since then each year, always giving high percentages of sugar. Some of its peculiarities are, viz, the unusual toughness of its stalk when overripe, and its great strength at all times.

It is hard, for some unexplained reason, to get a good stand. The seed is white, and local millers, with their crude appliances, have told me that they could get 30 pounds of flour from 1 bushel of seed, which, mixed with a small proportion of wheat flour, is preferred to buckwheat. The birds ravage the seed, and will select it from a hill planted with mixed Orange and Amber canes, leaving the other varieties unmolested. In order to be protected from these depredators and secure the seed, plots of sufficient size must be raised and calculations made for this loss. It has been found true here that they will not take quite all the seed from one acre in a season, consequently plots of 5 or 10 acres are comparatively protected.

The purity of the canes of this variety has been noticed as high as 77.92.

The cane has not been properly studied and the birds have taken nearly all the good seed from the acre raised this season.

MANUFACTURING.

I will confine myself in my report tome thods adopted for the first time this year.

SAWDUST FILTERS.

It has always been found that filtration of the juice through some medium that would remove the particles of matter mechanically suspended was necessary. For two years filter presses were used. It was found if the juice were alkaline it would filter much better, but gave highly colored products.

Last year Dr. Wiley advised the use of sand. This gave good results for a time, but gradually ran slow and failed to give satisfaction. The size of the filters in proportion to the juice worked, was very large and it soured easily.

EVAPORATOR.

In accordance with your instructions, I constructed an open evaporator to be run by crude oil (petroleum). Parallel brick walls, 13 inches thick, 34 feet long, and 24 inches high, were constructed. At one end was an iron stack, and at the opposite end were the burners. Upon the walls was placed an open evaporator of sheet-iron 2 feet high, 30 feet long, and 4 feet broad, divided by partitions 8 inches apart, 6 inches high, and 45 inches long. The juice entered the pan over the burners, discharged at the opposite end, traversing a distance of about 164 feet in twelve minutes.

The skimmings remained at the end over the burners and were easily removed. As this was the first time to my knowledge that crude oil had been applied to sugar work, I was able to collect little data to guide me. After examining personally the burners in use for steam-boilers, I finally adopted one belonging to H. W. Whiting, of Philadelphia. He advised me to place three burners at the end and insert in the brick-work at intervals of 1 foot inch pipes to extend completely through the walls and flues, and to be perforated with holes one-quarter of an inch in diameter and 3 inches apart. The intention was that air should pass through the perforated holes into the flue, and thus aid combustion.

The burners were made from 2-inch pipes with a T fitting open at the bottom to supply air; on the Bunsen burner principle, the oil passed through a quarter-inch pipe, through a cock into a 1¼-inch coil 1¼ inch in diameter, so placed as to receive a large portion of the heat from the burners; there is also a quarter-inch steam-pipe leading into the end of the pipe so that the oil and steam can be mixed as it passes into the hot coil or superheater, as it is named. When the oil is converted into gas from the superheater it passes into the Bunsen burner and is forced through it by another steam jet and burned from the opening.

In our first experiment Bradford crude oil was used, and in our final experiments black residuum of the refineries, which I have been informed is the product left behind after the light oils have been distilled off.

In practice we could find very little difference in the heating of the two oils. Lima oil could not be had in quantity less than six thousand gallons, consequently was not used.

It was found in starting the burners that a stack 10 inches in diameter was too small, the effect in practice being to cause explosion of gas.

A stack of 24 inches diameter was substituted; this stopped all explosions but wasted the heat. Dampers made of fire-clay were then used, and it was found that after the superheater was hot enough to generate gas freely the dampers could be safely closed. Care had been taken in constructing the dampers to arrange them so that there was left on the sides a space equal to about 12 inches square, after they were in. A further improvement in the heating was made by filling in next to the stack with dirt. This bank of earth was then extended back into the flue for about its length and paved on the top with bricks. There was left a space of about 9 inches between the pavement and the bottom of the evaporator, and in filling in the flue the combustion pipes were covered up for the length of the embankment. The combustion pipes directly in front of the flame were soon burnt out. No detrimental effects being perceptible from the loss of this air, it is safe to conclude that they were of no value.

The owner of the burners thought we would evaporate at least 15 pounds of water for each pound of oil burned and hoped we would reach 18 or 20 pounds. The record of the best day's work shows $7\frac{8}{10}$ pounds. It is but just to say that the evaporator was entirely too large for the work it had to do, and the walls had time to cool before starting each day. Now it is found that if the walls and surrounding mediums are much lower than the temperature of the gaseous product of the Bunsen burners, condensation takes place and the oil is fried, as it is called, instead of being generated into gas, which is wasteful in the extreme. One-third of all the oil burned was generally used in starting the burners each day. Another source of loss long evaded our researches. It was caused by using cocks to feed oil to the superheater. A common quarter-inch globe valve was substituted for the cock, which brought the burners under full control and enabled us to burn only one-quarter as much oil. I make the suggestion that pipes for supplying oil to the superheater should be less than one-quarter inch; that globe valves less than one-quarter inch be used, and that threads that regulate these valves be made as fine as possible so that they may have the most delicate adjustment. I can not tell the saving of all these apparent improvements because I had not time to get the record properly.

Taking the record as it is and counting the price of oil at $1.25 per barrel, about one-half of the water was removed from the diffusion juice of each ton of field cane for 31 cents per ton.

AUXILIARY HOUSES.

The auxiliary houses have been kept steadily in view during the season's work, and the fact has been remembered that the industry will spread and succeed at a much quicker rate if the capital necessary to conduct the business is kept as low as possible consistent with good management. The cost of building sugar-houses is reduced to a minimum and labor saved. There is no good reason to expect to make money out of the sorghum business unless conducted on sound business principles. The knowledge of the business is now advanced to such a point that there is nothing to prevent accurate calculations being made. The cost of the machinery, the work it can do, the labor required to run it, the cost of the cane, the yield and quality of the product can now all be closely estimated.

Sugar-houses built without definite ideas of the work to be done or machinery added piece by piece, without plans or contracts, and such machinery as clarifiers, as filter presses and bone-black drones added, with the expectation of only making white granulated sugar directly from the juice, will be certain to bring financial failure and disappointment to its projectors, unless the capital is heavy enough to stand the strain, or the parties are willing to make experimental work of their plants and pay the price for doing it. Notwithstanding the closeness with which all these calculations can now be made, the following should be remembered. I have never known a sugar-house of any kind to be made so complete and be in such fine running order that it could be depended on to make a commercial success the first season. Either its water arrangements will fall short of expectations, or the boilers fail to be large enough, or strikes and delays will detain the mechinery, or castings will be broken in shipping, or some minor points will be badly proportioned or too weak, foundations will prove not sufficiently secure, shafts will be found out of line, etc. All this will occur, not from any bad management, but because the nature of the work is such that the factory can only perform its task satisfactorily after being broken in on cane. The cane alone can give the necessary adjustment. Erroneous and disappointing calculations have been made by celebrated sugar engineers in making calculations for sorghum, by using well-known standard rules for the evaporation of water as a basis for calculation; and repeatedly has machinery proved suitable for Southern cane failed when applied to this work. The moral of all this is, that in constructing new works there should be only enough cane raised the first season to break in and test the sugar-house thoroughly in every part, in order that when the machinery is called upon the succeeding season, it would fulfill the work it had been calculated to do without delay or hindrance.

The expense of doing all this should be allowed for in the capital account.

In some sorghum houses, calculated to work 100 tons of cane a day, will be found strike vacuum pans of such large size that the cost of erecting them and the pumps necessary for their use, the large pipe fittings and other paraphernalia, will cost as much alone as would suffice to build an economical sugar-house of good size.

Experience had taught us that there is a limit to the size of sugar-houses, and that it costs very little more to man a 40-ton house than a 20-ton, and the proportionate cost of constructing is greatly in favor of the 40-ton plant. For sugar-houses of larger size I can not yet give accurate data with safety.

ABSTRACT OF REPORT OF PROF. W. C. STUBBS.

KENNER, LA.

Several varieties of sorghum were tried. These were planted on April 18, thinned to a stand, and cultivated in its order with the corn crop. Here flat cultivation was exclusively practiced during the season, while at the other two stations high ridges were required for drainage.

These plantings were made with a view of testing, by mill and laboratory experiments, the adaptability of sorghum as a sugar crop to Louisiana. If sugar can be made profitably from sorghum anywhere in the United States it should be done in Louisiana. Chemical analyses show a larger percentage of sugar and a smaller quantity of glucose in sorghum grown in Louisiana than anywhere else in this country. At least the published analyses now at hand verify this assertion. Again, could our sugar-planters be persuaded that sorghum could be made to yield a profitable quantity of sugar, say, even 1,000 pounds per acre, they would soon adopt it as an adjunct to the cane crop.

Again, there are vast tracts of rich alluvial lands in the middle and northern portions of the State which are too far north for cane, and which will grow excellent crops of sorghum. These lands are now in cotton, but could it be demonstrated that they could grow sorghum profitably, central factories would spring up in every direction and this crop would supplant cotton in part if not entirely.

With these possibilities in view, the director has persistently planted sorghum for three years upon the sugar experiment station and attempted every year to make successfully sugar from it by the milling process. Chemical analyses have shown that our juices were rich in sucrose and low in glucose, but our sugar-house experiments have failed to extract it successfully. We have made the *masse cuite* full of grains, but our centrifugals failed to purge. All this was due to the starch present in the juice (extracted by pressure with the mill), which, during the subsequent process of concentration, was concentrated into dextrine, and this substance, our *bête noir*, prevented the elimination of the sugar. Our past experiences have demonstrated the inapplicability of the crushing mill to sorghum. They have also shown that high temperatures must be avoided. Therefore new methods of extracting the juice and processes of cooking in vacuo must be resorted to before we can successfully extract sugar from sorghum.

From our past experience with sorghum it was inferred that our crop planted on the 16th of April would not be ready for the sugar-house before the 1st of September. Accordingly we contracted with Messrs. Edwards & Haubtman to deliver the machinery by the 15th of August, thus giving us fifteen days (ample time) for its erection and preparation for work. Messrs. Edwards & Haubtman failed to deliver until the 23d instant, which failure, in connection with the unprecedented storm of the 19th instant, which prostrated completely our sorghum, proved most disastrous to our successful manufacture of sugar.

In 1886 sorghum planted April 5 was harvested 13th September. In 1887 sorghum planted April 21 was worked up September 23. Both years they were worked at full maturity, excepting the Early Amber and Chinese, which were ripe in July of each year.

It was fair therefore to calculate that, without any natural intervention, the sorghum this year would not be ready for the sugar-house before the middle of September; and had not the storm prevailed the date of delivery of Messrs. Edwards & Haubtman would have still afforded us ample time to have completed erection before the maturity of the crop. Either alone would not have proven disastrous; both together were fatal.

STARCH IN SORGHUM.

With green canes just heading no indications of starch are given by iodine. If there were any blue it was completely obscured by the intensely brown coloration. This brown coloration indicated dextrin and other forms of soluble starch.

With well-matured canes iodine gives an intensely blue color towards the top, decreasing in intensity towards the butt. Canes occupying an intermediate condition between these extremes, or in that stage of growth when maturity begins to appear as indicated by the presence of sucrose in the lower part of the stalk, starch will be found in the butt but not in the top.

The above conclusions of Mr. Hutchinson have been fully confirmed by subsequent experiments; and it is not unusual in our laboratory now to prognosticate the amount of sucrose in a cane by the presence of starch, so intimately are they associated. Both sucrose and starch seem to be formed simultaneously—the former from glucose and perhaps other bodies, and the latter from dextrine and other soluble forms.

Glucose occurs in largest quantities when the polariscope gives no indication of sucrose by single polarization. In a sample of green cane, in which there was no starch and by single polarization no sucrose, but by double polarization 1.53 per cent., as high as 7 per cent. of glucose was found. As the cane from which the above sample was selected matured, repeated analysis made at short intervals showed that the glucose decreased until at maturity it reached as low as 0.8 per cent.

EXPERIMENTS IN DIFFUSION.

Without entering into the full details of daily work, the following taken from our large amount of records will suffice to illustrate fully the work performed.

Considering the very low character of the sorghum worked the results obtained are quite promising.

Wednesday, September 12.—Having repaired the defects, work was begun at 9.30 o'clock and continued until nineteen cells had been filled. Everything worked admirably, except the heaters, which were not under control, and hence varying temperatures used in diffusing. Weather very warm and much suffering experienced by everybody at work, particularly by the men at the diffusors and clarifier.

It was utterly impossible, from the varying amounts of sucrose in the canes used,

to get anything like uniform results, either on the juices or chips. There were drawn four clarifiers of about 500 gallons each. The last two were very dilute owing to the excess of water used in washing the chips after cells were filled. This juice was heated with lime and brought to neutrality; heated and blanket, which was quite insignificant, removed. It was then settled and clear juice run into the double effect and concentrated.

There was a large quantity of settlings and some scums, which were weighed and analyzed and thrown away to avoid interfering with the well-clarified sirup. The following are weights obtained:

	Pounds.
Sirup	1,562
Settlings and scums	1,070
Sugar	49
Molasses	752

The following are the notes of diffusion: Every effort was made to hold the temperature at 200° Fahr., but until the battery had been used in one entire round this is almost impossible to do, since sending in quickly water heated to 200° Fahr. into cold iron cells filled with cold. chips, the loss of heat by radiation and convection is very great. Six minutes were allowed for the diffusion of each cell after the hot water was turned on. Every effort to grain in the vacuum pan proved abortive, as the following notes of Mr. Baldwin, who has charge of the pan and was assisted by Mr. Barthelemy, will show:

"Part of juice concentrated in double effect on first watch; remainder on second watch, when the juice got very hot, 180 degrees, and was emptied in cars to cool; finished concentrating on morning of 13th, at a temperature of 155 to 160 degrees Fahr. Juice dark-colored and some feculent matter present. After mixing sirups started vacuum-strike pan at 2 p. m. on 13th; temperature 138 to 140 degrees Fahr.; very thick; nothing but candy would form in the pan. Allowed to stand half an hour until candy dissolved, but no grain. Stood again one hour; at 7 p. m. still no grain. Cooked very thick and remained in pan until 2 p. m. next day, when it was all boiled to string sugar and put in the hot-room. Injured some by being cooked to candy.

"In the hot-room it at once began to grain, until the wagon was quite solid with small grains of sugar.

"It was centrifugaled and gave the following results:

Sugar	pounds	49
Molasses	do	752

Recapitulation.

Cane contained	pounds sucrose	349.75
Sirup contained	do	273.22
Scums contained	do	20.33
Chips contained	do	56.20
Sugar contained	do	44.58
Molasses contained	do	228.61
Sugar obtained	pounds per ton sorghum	15.5
Molasses obtained	do	237.1

After the analyses of the mill juices were known little or no hope was entertained of successful sugar results. Indeed, it is wonderful, with such juices and after such treatment, that any sugar should be obtained.

September 17.—It has often been published that neither sorghum nor its juices will stand transportation or delay in working them up after being cut. That such is not the case with us is abundantly proven by the following and many other experiments during this season. On September 16, Mr. Barrow, assistant at the State experiment station, was sent to Baton Rouge to harvest and ship a car-load of sorghum from that station to this. By 9 a. m. on the morning of the 16th, he had cut and loaded a closed car with Early Orange sorghum. This sorghum was quite wet from dew, and had its leaves and tops still on, conditions making fermentation quite feasible to almost any crop. It was delivered at Kenner by Mississippi Valley Railroad at 7 p. m. of same day. It was unloaded and delivered at sugar-house at 12 m. of the 17th, and worked up as delivered. This cane had been badly blown down by the storm of the 19th, and was filled with suckers several feet long, now in full heads. It was quite low in sugar, as the following analysis of selected stalks made on September 11 showed:

	Per cent.
Total solids	11.9
Sucrose	7.8
Glucose	4.52

Began diffusion at 9 a. m. Filled twenty-three cells with chips and drew off thirty-one cells of juice. Finished in early evening, after two slight detentions. Cells diffused sixteen minutes each, except three times, when interrupted. The temperature varied from 150° to 200° Fahr. The juice was boiled to a sirup in double effect and made into string sugar in the vacuum pan. Boiled all night, finishing the next day. The string sugar was run into the hot-room, where it was grained into almost a solid mass. The following are the amounts used:

		Pounds.
Weight of canes		13,266
Less weight of—		
Tops	2,445	
Leaves	1,785	
Trash in yard	1,558	
Chips not used	82	
		5,876
Clean cane used		7,399

The juices from this were concentrated into a sirup, giving 1,491 pounds; scums thrown away, 313 pounds; juice made into molasses, 259 pounds.

The following are the laboratory results:

	Pounds.
Sugar obtained	115
Molasses obtained	672
Sugar per ton of sorghum	31.4
Molasses per ton of sorghum	181.8

Recapitulation.

Cane contained (calculated)	pounds sucrose	435
Sirup made into sugar contained	do	328
Sirup made into molasses contained	do	57
Scums contained	do	7
Chips contained	do	32
Fiber in cane	per cent	15.5

[Variety: Early Orange.]

	Total solids.	Sucrose.	Glucose.	Glucose to sucrose.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
Mill juices	11.4	7.0	3.33	48
Do	11.3	7.0	3.58	51
Do	11.7	6.9	3.30	48
Diffusion juices		3.2	1.79	56
Do		3.95	2.00	51
Do		3.00	1.92	64
Do		3.90	2.17	55
Do		3.90	2.32	59
Do		4.10	2.00	48
Do		3.50	1.72	49
Do		3.70	1.46	39
Do		4.10	1.73	42
Do		3.50	1.50	48
Do		3.60	1.66	46
Do		4.20	1.62	38
Do		3.90	1.70	44
Do		3.30	1.60	48
Diffusion chips		.3	.14	47
Do		.3	.18	60
Do		.25	.16	64
Do		.35	.149	43
Do		.25	.14	56
Do		.15	.13	90
Do		.15	.10	40
Clarified juices		3.6	1.85	51
Do		3.9	1.60	41
Do		3.1	1.57	51
Do		1.8	.99	55
Do		1.3	.56	43
Do		1.1	.54	49
Sirup		22	11	50
Scums		4.2	2.22	53
Sugar		92.1	2.94	
Molasses		34	22.72	

Here, as before, the dilution was great owing to the water used in washing the chips after cells were filled. This cane had nearly a constant composition, and from glucose ratio there has been little or no inversion either in cells or in concentration of sirup. In fact, when water at 200° Fahr. is sent into cells and maintained there for six minutes at this temperature, little or no inversion took place, notwithstanding the weather-gauge showed this day a maximum temperature of 83° Fahr.

September 20.—The following canes were selected for this run: Link's Hybrid, White India, White Mammoth, and the second planting of Early Amber. The suckers, of which there were many, were removed by hand. Filled nine cells. Everything worked well.

			Pounds.
Weight of cane used			5,078
Less weight of—			
Tops	pounds	812	
Trash	do	653	
Suckers	do	208	
Chips not used	do	74	
			1,747
Clean cane used			3,331

Juice neutralized with lime, blanket removed, settled, concentrated in double effect and grained in vacuum pan; then emptied into car and run into hot-room, where it solidified into crystals of sugar of small size.

	Pounds.
Weight of sirup	695
Weight of scums, etc	150
Weight of sugar	40
Weight of molasses	235
Sugar per ton	24
Molasses per ton	141

The following are laboratory results:

	Total solids.	Sucrose.	Glucose.	Glucose to sucrose.	Variety.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	
Mill juices	10.6	6.7	1.48	22	Link's Hybrid.
Do	14.1	10.0	1.25	12½	White India.
Do	10.5	6.9	2.14	22	White Mammoth.
Do	10.7	6.5	1.92	29	White Amber (Nebraska).
Do	10.4	5.4	3.12	57	White Amber.
Diffusion juices	4.8	3.05	1.13	37	
Do	6.0	3.50	1.51	43	
Do	6.0	3.70	1.51	41	
Do	5.2	3.20	1.57	49	
Do	5.6	3.25	1.61	49	
Diffusion chips	....	.20	.16	....	
Do	....	.30	.14	....	
Do	....	.20	.13	....	
Do	....	.10	.12	....	
Do	....	.10	.12	....	
Clarified juices	5.9	3.5	1.39	29	
Do	2.1	1.4	.51	38	
Sirups	32.94	17.5	7.04	40	
Scums	....	1.7	.73	41	
Sugar	....	92.2	2.93	....	
Molasses	....	34	20	....	

RECAPITULATION.

Sucrose in—		
Sirup	pounds	121.62
Scums	do	2.55
Chips	do	10.56
Sugar made	do	36.88
Molasses made	do	79.90
Fiber in cane	per cent	15.04

CONCLUSIONS.

While the present season was in Louisiana a most disastrous one for making sugar from sorghum, yet the successful application of diffusion in the extraction of the juice from both sorghum and sugar cane has been abundantly proven.

From sorghums of fair quality, such as were raised on this station in 1886 and 1887, it is certain that a large quantity of sugar could be obtained. From Early Orange this year, with only 9 per cent. sucrose and 3.33 per cent. glucose (glucose ratio nearly 50) 31.4 pounds sugar were obtained to ton of sorghum. This same variety showed in 1886 a sugar content of 13 per cent. with a low glucose ratio, and in 1887, a less favorable year, sugar content of 10.5 per cent. and only 13 as the glucose ratio. Could such cane have been diffused this year, a yield of fully 100 to 125 pounds per ton might with reason have been expected.

However, this station will repeat again the experiments next year, with more promise of success.

REPORT OF HUBERT EDSON.

DOUGLASS, KANS.

After one or two trials to test the machinery of the house, the regular manufacturing season at Douglass commenced September 14, and continued with what regularity was possible up to October 25.

There is no doubt but that the Early Amber was ready for work by the middle of August, and possibly earlier. When I arrived in Douglass, August 26, I found several fields that had passed maturity. This cane, however, contrary to experience elsewhere, did not deteriorate in any marked degree till some time after reaching its maximum sucrose. When the house was closed we still had Amber coming in in large quantities and containing sucrose enough to warrant working it.

Besides the Amber, the two other varieties chiefly grown were the Orange and a cane identified by Mr. Denton, of Sterling, Kans., as the Chinese.

The Amber and Chinese contained highest sucrose and lowest glucose, with the advantage slightly in favor of the Chinese. The Orange did not do as well as was expected, but it was planted so late in the season that it did not have time to mature.

The exceedingly variable nature of the cane brought in was a source of constant annoyance, nor would the appearance of the stalks be any criterion of the quality of the juice. One field of 30 acres which had been ordered hauled in before any test had been made of it was found, on the arrival of the first load, to contain but 4.50 per cent. sucrose, with almost as much glucose. This cane was, judging by its appearance, as good as any worked during the season, but repeated tests of samples taken from different parts of the field failed to show in a single instance enough sucrose to warrant working for sugar. Numerous instances of this same thing were found throughout the season and the cane needed the closest watching.

One thing it would be well to impress upon the sorghum-grower, and that is, the necessity of growing small or medium-sized canes. From numerous trials of comparative samples, the highest sucrose and lowest glucose were always found in the smaller canes. Fields, also, where the small and slender canes predominated were always of superior quality. The best cane analyzed at Douglass was a sample from a field sowed for fodder, in which the seed had been scattered broadcast on the land, and as a consequence grew very small. Of course I do not mean to advocate the sowing of sorghum seed to grow a product for the sugar-house, as then too large an amount of sheath and leaves would be obtained, but it is necessary to avoid large, rank stalks, as the desire is to obtain a high content of sucrose.

THE SUGAR-HOUSE.

The house was designed to work 100 tons of field cane daily. The Hughes cutter and shredder were used. The trap-door just before the cutter through which it was intended to pass the seed heads failed to work satisfactorily. This was due in part at least to the heavy feed which it was necessary to keep on the narrow carriers in order to supply the battery with chips. The shredder when properly adjusted did excellent work, tearing the chips into a pulp if required.

The main feature of the house was the diffusion battery. This is known as the Hughes system of diffusion, and is described in Bulletin 17, Chemical Division, Department of Agriculture. The one at Douglass differed slightly, however, from the one described there. The main battery contained ten cells, with the baskets for holding chips used in his process, and in addition to these an outside cell was placed so that the arm from the large crane could reach the basket while immersed in it.

An extra crane was necessary to raise and lower the baskets in this cell, as it had to be worked without connection with the main battery.

The object of the cell was to give a dense diffusion juice, and thus save evaporation. As the battery progressed, the heaviest juice from two cells was drawn into the outside cell, and there received two baskets of fresh chips before being dis-

charged. This, as far as I was able to see, did not attain the object claimed for it, as no fresh chips ever reached the main battery, and consequently the juices were more dilute and needed the addition of two baskets of fresh chips to bring them to a normal diffusion juice. It is certain at least that the extra steam-power required to run the outside cell would a great deal more than suffice to evaporate any less dense juice that might be obtained.

Before passing to the work done by the battery as a whole, it is but just to say that there were mechanical defects in the construction which, if they could have been remedied this season, would have materially assisted the quality of the work. The bottom of the baskets, instead of being single and swinging to one side, were doubled and hinged to a cross-bar extending from one side of the basket to the other. As a consequence of this arrangement the emptying of the exhausted chips was a very difficult matter. But, on the other hand, a basket constructed strong enough to permit a single bottom would be altogether to heavy to use where so much of the work is done by hand.

The average sucrose of the fresh chips for the season was 9.88; for the exhausted chips, 1.72. The extraction of sucrose, therefore, was 9.88—1.72 = 8.16 ÷ 9.88= 82.59 per cent. This extraction was accompanied by a dilution of 52.45 per cent., 16.89 (Brix of fresh chips)—8.03 (Brix of diffusion juice); 8.86÷16.89=52.45 per cent. With a dilution of this sort in a closed battery practically all the sugar would be exhausted instead of 1.72 per cent. left in by the Hughes process.

It was noticed that a regular ratio existed between the exhaustion and the dilution. As the dilution was increased the extraction became better, and *vice versa*.

Besides the amount of sugar left in the chips there was an unknown waste of immense quantities of juice from the drippings of the baskets in transferring them from the eleventh cell to the cells of the main battery. This loss it was impossible to gauge, but to any one who saw it it was evident that no inconsiderable amount was lost.

Nothing which we could think of to make the battery a success was left undone. For part of the time I shifted all of the laboratory work to my associate, Mr. Fuelling, and took charge of the battery. This I was prepared to do from a previous year's work with the inventor of the system, with whose plan of running the battery I was consequently familiar. Although the quality of the work was improved after the change I instituted, it was so far from being good diffusion that nothing was left to do but to condemn the apparatus.

THE DIFFUSION JUICE.

The juice as it came from the cells was full of finely divided fiber which had come through the perforations of the baskets, and was also of such a dirty-black color that it was impossible to clarify it.

Sulphites of lime were used for awhile, as were also superphosphates, but both were so full of sulphuric acid and accomplished so little that they were discontinued.

The juice probably acquired some of this color from its acids attacking the iron vessels in which it was kept so much of the time, but the main cause was the passage of large quantities of seeds through the diffusion battery along with the fresh chips. As was mentioned before, the cutter was too narrow for the capacity of the house, and a very heavy feed was kept on the carrier, preventing the seed heads dropping down through the trap-door designed for that purpose.

To illustrate that these seeds were the cause of the discoloration, Mr. Fuelling diffused two beakers full of chips, the one of them containing a few seeds and the other none.

The one with the seed gave the black color characteristic of the diffusion juice from the house, while the other gave a perfectly limpid liquor. I endeavored to have the superintendent of the house make a run, cutting the tops off in the field, but he failed to do so.

DISPOSITION OF EXHAUSTED CHIPS.

During the first part of the season a long carrier was used to convey the chips to the yard. It was intended to extend this as the yard filled, but the chains broke so often that this plan was given up and the chips taken off in carts.

The centrifugals did very poor work throughout the season, but so little sugar was extracted by the battery that it was not considered necessary to get new ones.

SUMMARY OF WORK.

During the season 2,167 tons of cane were worked.

Allowing 25 per cent. off for tops and leaves, this would amount to 1,623 tons of cleaned cane; 45,000 pounds of 94.45 polarization were obtained, or 26.2 pounds per ton of clean cane.

Eliminating the loss in the centrifugals, which would have been remedied if enough sugar had been obtained to justify it, the great loss in working the house was in the battery.

Certainly with two years such work as this apparatus has done there will be no more danger of its being used again in a sugar-house.

ABSTRACT OF REPORT OF E. W. DEMING.

CONWAY SPRINGS, KANS.

The experiments were conducted in connection with the work of the Conway Springs Sugar Company.

This company was incorporated April 10, 1888, under the laws of the State of Kansas, with an authorized capital of $100,000. Its officers are: G. W. Fahs, president; E. E. Baird, vice-president; G. B. Armstrong, treasurer; E. W. Deming, secretary and manager.

The factory was equipped with two tubular boilers of 150 horse-power each; two 30 horse-power high-speed engines; 3 hanging Hepworth centrifugals, with mixer; one 7-foot vacuum (dry) pan from R. Deeley & Co., New York. Hot-room, with fifty sugar wagons. Lillie double effect from George M. Newhall & Bro., Philadelphia. Diffusion battery from Shickle, Harrison & Howard Iron Company, Saint Louis; three cutters, with necessary clarifiers, skimming pans, and storage tanks. One dynamo of 100-lamp capacity, incandescent, provided lights for the building. Two sets rolls and a fire dryer for crushing and drying exhausted chips and one small open evaporator.

The diffusion battery consists of sixteen cells each 8 feet long and 35 inches in diameter, wrought-iron shell with similar castings, doors, and counter-weights at each end, provided with solid-rubber gaskets that gave satisfaction under a 30-pound per inch pressure. One heater for each cell, made of 6-inch wrought pipe containing 11 one-inch brass tubes 5 feet long; the connecting and circulating pipes were of 2½-inch wrought iron. The battery was placed in two lines of seven cells each, with one across each end, and supported on wooden posts, beams, and cross-beams 8 feet from the ground; each cell would hold 1,400 pounds of chips. The cost of this battery with pipe and fittings was $5,500; its work was in every way satisfactory. The exhausted chips were discharged into a chute of sloping sides, directing them into a drag of peculiar construction, delivering them into an elevated chute from whence a cart removed them. This apparatus worked well.

The double effects are each 4 feet in diameter and 18 feet long, placed on end; each has 70 three-inch brass tubes 8 feet long placed vertically; ends of tubes properly secured in plates, steam being admitted to the chamber about the tubes. Pumps draw the liquor from bottoms of pans discharging at the top, passing through perforated screens to the upper plate, from which it overflows a thin film of juice down the inside of all tubes alike; the evaporation occurs in the tubes; a vacuum is maintained throughout the tubes and circulating pipes. The vapor was removed at lower end of tubes, with suitable circulating pumps and a slight change in the tops to facilitate cleaning. They will not only have large capacity but unusual merit for handling sorghum juices. These pans, by reason of mechanical defects not difficult to overcome and the rapid formation of scale upon the heating surface extremely difficult to remove, caused some considerable delay to the work.

The first or second cutter, Hughes style, consisting of two heavy balance-wheels 36 inches in diameter placed 32 inches apart on a 3-inch shaft, two knives placed horizontally, connected the face of the balance-wheels. The dead-knife was placed 8 inches below center of the shaft, thereby making a bevel cut on the cane; space between end of drag and dead-knife 23 inches; this permitted the seed to readily escape the knives by falling into a drag.

Power was transmitted by a belt, the cutters making 200 revolutions per minute, cutting into 1-inch sections a bed of cane 30 inches wide and 6 inches deep. This cutter proved deficient in both strength and capacity. One-third of the delays and losses attending the work are traced to this source. Below the cutter was a single fan 20 inches in diameter and 30 inches long, having a motion of 600 revolutions per minute. Its work was especially fine.

The two shredders were each 20 inches long and 8 inches in diameter, provided with four knives held in place by a peculiar arrangement at the ends, leaving the face of cylinder free of openings; motion, 1,200 revolutions per minute; doing satisfactory work.

Three clarifiers of No. 10 iron, round, 5 feet in diameter and 30 inches deep, with cone-shaped bottoms. Two-inch copper coils were used. They lacked scum pockets; otherwise their work was satisfactory.

The cane shed consisted of two floors, each 10 feet wide and 150 feet long, separated one above the other by a space of 4 feet. As a means of storing cane this apparatus worked well.

An open pan, iron, of two channels, each 12 inches wide and 12 inches deep and 20 feet long, filled with three-quarter-inch copper coil, was at first used with steam as a skimming pan to aid clarification.

Later steam was dispensed with and the pan operated as a continuous-flow settling tank, giving better satisfaction and suggesting a possible manner of constructing a rapid system of continuous-flow settling tanks.

The cane is received from the farmer upon specially constructed racks. The wagon is driven on a turn-table by which it was squared about, then backed a few feet against an ordinary wagon scales on which was a raised platform 3 feet high; an iron hook was secured in the two ropes placed around the load by the farmer; a friction clutch at the opposite end of the cane shed, nearly 200 feet distant, drew the load over the rear end to the scales. Here it was weighed net, and the farmer's ropes removed. An endless sling was then thrown over the cane, the same power taking it into one of the floors comprising the cane shed, where it was left for night run or taken directly through to a small downward incline where two men pulled it apart, feeding to three chains with attachments that carried it 1 foot above a cross-drag leading to the cutters. The feed was regulated by stopping and starting this chain. This drag leading to first cutter has a motion of 40 feet per minute, carrying the cane in bundles a few inches of space between the tops of one bundle and the tops of the next; this permitted seed to drop freely. Seed was hauled directly to the field and left in small piles; that required for sugar work next season is carefully selected by hand, tied up into bundles of eighteen tufts, two bundles then tied together, and so hung up in a dry place. The rest is stacked, allowed to pass through a sweat, and thrashed in February. It is sold in large quantities at good prices to ranchmen, who sow it for fodder for stock. The inch sections of cane as they are cut fall into a strong blast of air direcly underneath, by which the leaves and the sheaths are removed. By means of a link-belt drag the cleaned sections are conveyed into the main building to an elevator, taking them above the roof, where they are discharged into the hopper of the shredder and reduced to a pulp, which falls into a carrier passing over the diffusion battery. Openings in bottom of this carrier permit the cane chips to be spouted to cells on either side.

Although the semi-sirup contained a purity often above 70, it was difficult and generally impossible to start a grain in the pan; a strike thus boiled to grain produced exceedingly fine grain difficult to purge and invariably dark in color, no better than a number of early strikes boiled to string.

These fine, gummy, dark sugars dissolved in clarified juices were used to start the grain ; an amount equal in weight to one-fifth that of each strike produced a fine sugar of medium-size grain remarkable for its uniformity of grain, color, and purity. All sugars were taken to the mixer and passed through the centrifugals as speedily as possible to remove them from contact with the black molasses.

The entire water supply was obtained from a bed of gypsum 65 feet from the surface, and was positively unfit for use in either the boilers or the diffusion battery. The injurious effects of this water was observed early, Dr. Wiley being the first to suspect the true cause. By the use of this water for diffusion there is a loss (estimated) of 22½ pounds of sugar from each ton of cane worked, or 35 per cent. It ruined the molasses, and to this gypsum is attributed, directly or indirectly, nearly two-thirds of the annoying and expensive delays and losses incident to the present season's work.

Canes of unusual richness were worked, the battery secured a good extraction, the entire evaporation occurred in vacuum with but slight inversion of sugar; but large yields of sugar did not follow.

The analyses of molasses from the sugars explains much, many of them showing the relative sugars four and even four and one-half to one, yet so engulfed with a mass of gums, black and bitter, as to render impracticable any attempt to secure second sugars.

In my opinion the estimated loss of sugar due to the use of this water should be doubled. I would respectfully ask critically inclined persons to keep these facts in mind when reviewing the accompanying tables, which contain notwithstanding some interesting and reliable information.

The farmer looks upon this industry as one created for his special benefit, and when considered from his stand-point, as judged by its agriculture, can see only magnificent successes for all sugar work. An average crop of cane as grown in this section at $2 per ton equals in value the land upon which it is grown.

No crops are grown with more certainty ; others, corn especially, in most localities of this section are not sure every season. One farmer growing 30 acres re-

ports an average of $13\frac{1}{2}$ tons per acre. Some small pieces produced more, the average being $10\frac{1}{2}$ tons per acre. Ten thousand acres at $2 per ton could easily be contracted for delivery next season. The farmers are not slow to see the advantages offered in growing cane at these prices.

The soil of this section can be called neither clay nor sand, being light, loose, not sticky, light in color, contains little organic matter, and produces only a medium-sized stalk of corn or cane.

But one trial run was made, worked by itself; 43 tons of cleaned cane, from which was obtained 3,850 pounds of sugar of 98 per cent. purity, and 1,000 gallons of molasses, being 90 pounds of sugar and 23.2 gallons of molasses from each ton. The laboratory work under the direction of Dr. H. W. Wiley, in charge of Prof. E. A. von Schweinitz, assisted by Mr. Oma Carr, has been most satisfactory. The information gained through their labors will prove very interesting and valuable to all friends of this industry.

I am well satisfied no well-regulated sugar works can be successfully operated and the best results obtained unless a complete chemical control of the every-day work prevails.

The following facts may not be out of place: This enterprise was no exception to those preceding in respect to starting late in the season, after the crop was planted, as it were. Less than three months intervened between the placing of orders for the machinery and the date of ripening of the first planted cane. The factory was two weeks in starting, and the other end of the season shortened by burning of the boilers November 4, leaving 75 acres of most excellent cane that was rich in sugar.

Gypsum had a most disastrous effect upon the boilers; frequent stoppages of work were required to clean them. By reason of excessive scaling of boiler shell and tubes the efficiency of the boilers was greatly reduced.

The following figures relative to this plant were taken from the books of the company and are reliable:

Cost of sugar-works plant	$44,547.72	
Less cost of water-works plant	6,000.00	$44,547.72
	38,547.72	
Donation city water-works bonds	12,800.00	
Received from United States Department of Agriculture	10,000.00	
Farmer's stock for cane paid in	4,500.00	27,300.00
Cost to present owners		17,247.72
Cost of labor	5,896.02	
Less labor on water works	1,500.00	4,396.06
Cost of fuel		3,096.33
Cost of cane		5,980.00
Cost of incidentals, barrels, etc		1,364.37
		14,836.72
100,000 pounds sugar, at $6\frac{1}{2}$ cents		6,500.00
100,000 pounds sugar, 2 cents, State bounty		2,000.00
36,000 gallons molasses, at 12 cents		4,320.00
6,000 bushels seed, 50 cents (estimated)		3,000.00
		15,820.00
Gain		983.28

Five thousand dollars were paid to railroads for freight transportation. The cost for coal and labor to handle 1 ton of cane is $2.50; much coal was used for testing machinery, water-works, etc. Profit per ton over cost of production, 33 cents. Taking the season as a whole the plant was operated at less than half its capacity with no decrease in cost of labor. Fully 150 tons could have been worked with the same labor and an increase of 20 per cent. of fuel, making the value per ton of cane worked over cost of production $1.62, or $243 per day.

For working a 200-ton plant costing, perhaps, 20 per cent. and fuel 25 per cent., would show value of product over cost of production of $3.60 per ton, or $720 per day.

These yields are based upon results of this season's work—60 pounds of sugar and

16½ gallons of molasses from each ton, which certainly is 20 per cent. less than may reasonably be expected by the use of good water.

The average quality of sugar as placed upon the market from these works was equal to the best in purity, but stained slightly by contact with black molasses; it has a hard, firm, medium-sized, well-cut grain, was dried thoroughly, and, unlike all fine-grained sorghum sugars heretofore produced, does not cake or become hard in the barrel. It stands next to granulated in price and sweetening power, the jobbers selling at 6¾ cents per pound more of this sugar than all yellow sugars combined. Confectioners appreciate its sweetening power. The molasses was very dark in color, sharp and bitter to the taste, classed but little better than black-strap; with pure water the quality should be improved and the selling price increased to 18 or 20 cents per gallon.

The Department of Agriculture, under the direction of Dr. H. W. Wiley, who first advocated and practically applied the process of diffusion to the manufacture of sugar from sorghum, has made it possible to secure practically all the sugar in the juice, this being the first and greatest step towards the establishment of the industry; the next greatest and scarcely less important step still awaits a solution. I refer to the clarification of sorghum juices. The methods now employed for this purpose are borrowed from the sugar-cane work of Louisiana, being merely the addition of lime and removing what scums appear on the surface. Analysis shows the amount of sugar in each ton of cane, averaging the whole season, to be 249 pounds; the glucose would hold in solution 66 pounds, leaving 183 pounds available did not other solids, as gums, starch, coloring matter, etc., also restrain 1.4 times their equal of sugar from graining, until a possible yield of 100 pounds or less from each ton of cane is our best work. Must we stop here and permit the loss of one-half or more of the sugar found in the cane? The task is not an easy one, as the many know who have considered it even briefly, but its importance and necessity demand that we sit not idly by. The people of the whole southwestern portion of this State, to my personal knowledge, are enthusiastic upon the question of sorghum sugar; a failure any season to grow good sorghum is not recorded. The establishing of sugar works would bring under cultivation lands now considered of little value except for growing sorghum, and, fortunately, will produce a sorghum of the very best quality for producing sugar.

These facts are fully appreciated, and every town, many without water and others without railroads, aspires to the possession of sugar works.

Daily during the working season committees, delegations, and individuals visited the sugar works, leaving full of confidence in the work.

A number of factories could be erected in this section next season if experienced men could be found to operate them.

MR. DEMING'S DIRECTIONS FOR RAISING CANE.

Much depends on a good stand from the first planting. No filling in will be allowed. If necessary to replant any portion it must be replowed, cultivated, or listed over. The field should first be cleared of all trash, such as stalks, weeds, and bunches of grass. This is best done by raking and burning. Unless a lister is used a good seed bed, such as for wheat, should be provided, and the seed deposited in fresh, moist earth, deep enough to insure moisture, yet not beyond the sun's warmth. This varies from one-half inch in depth on heavy clay soils to 3 or more inches on light, loose, sandy soil.

It is essential that the seed be planted at an even, uniform depth to insure its coming up and ripening early, and the seed must under no circumstances be dropped or covered by hand. For loose sandy soils a lister is a good planter. A good garden drill may answer, and under some circumstances a forced wheat drill, having all the holes, except the two next the outside ones, closed, but for a prepared seed bed a regular two-horse corn-planter, with or without a drill attachment, gives the best result, planting at a uniform depth, and the wheel firming the soil about the seed, causing it to germinate and grow more rapidly with a better start of the weeds. Unless the planter has broom-corn plates, which are the best, the holes in the corn plates should be partially closed with lead, babbitt, cork, or leather, until they admit of the passage of not more than four or five seeds at each movement of the plate. A slight excess of seed should be planted, and the hoe used to properly clean it out. This should be done invariably before the cane is 4 inches high. Good soils will produce a stalk of cane for each 4 inches of row space. When the rows are 42 inches apart, two stalks should be allowed a space of 10 inches, three stalks 18 inches, four stalks 30 inches, six stalks 42 inches, and never more than six stalks in any one bunch, no matter how spaced.

Foul land is easiest tended when planted in checks, and all lands so planted pro-

duce more sugar but a smaller tonnage than when planted in drills. The cultivation should be merely upon the surface, to avoid cutting and otherwise disturbing the roots, checking their growth, and inducing a growth of suckers to sap the parent stalks and retard their development.

All that is required is to keep the grass and weeds in check, and all cultivation should cease when the joints appear, as any interference with the roots at this time results most seriously. One well-matured stalk will grow on the space occupied by two small ones, is as heavy as six small ones, and contains more juice sugar and less impurities in proportion to its weight. The seed and leaves are less than 25 per cent. of total weight of the large stalks, while with small canes the loss from this source may reach fully 50 per cent.

To plant cane upon new ground the turned sod should be quite thin, but evenly and smoothly laid. The seed should be planted with a two-horse corn-planter, provided with a rolling coulter to cut and not displace the sod, depositing the seed just underneath the subsoil. The sod acts as an excellent mulch to retain moisture and prevent the growth of grass and weeds, no cultivation or further attention, except thinning, being necessary until harvest time. A good practice for planting cane upon old ground is to plow the land at any time during early spring, but do not harrow. At planting time take a two-horse cultivator, place three small shovels upon each beam, spread and fasten the beams so that the shovels will work up a space for two rows, each 4 inches deep and 12 inches wide. Let the planter follow soon, depositing the seed in the center of this worked-over space. There will be no weeds or grass for 6 inches upon either side of the plants, and the cultivator will care for the space between the rows. Cane deteriorates very rapidly when cut, lying on the ground in bunches, exposed to the sun and drying winds, a few days of such exposure changing the sugar into glucose. Cane should be delivered the same day as cut, the only exception to this rule being to cut and load on the wagon the evening before what can be delivered early the next morning.

Next to the importance of properly thinning the canes, the necessity of having well-matured, freshly cut, promptly delivered cane is the most important point connected with the agriculture of this business.

Instructions for converting an ordinary hay-rack into a cane-rack will be furnished by the cane agent. Each wagon must be provided with two ropes, each three-fourths of an inch in diameter and 35 feet long, by which the cane is unloaded. The cane must be loaded so the tops project over the right side of the rack, facing the team.

ABSTRACT OF REPORT OF E. A. V. SCHWEINITZ.

CONWAY SPRINGS, KANS.

The results of analyses of whole canes are recorded in table No. 1. The canes were topped and stripped, and the juice expressed by means of a small hand-mill. The average amount of sucrose in the juice was about 2 per cent. higher than the average of any crop heretofore worked. The highest per cent. was found in sample No. 162, taken from a load of Sterling Orange. The lowest percentage of sucrose was noted in two samples of mixed Amber and unripe Orange on September 4 and September 10. The best samples taken during the working season were Nos. 27, Amber, 352, Orange, and 374, Link's Hybrid. The Amber cane after being cut, if left lying for any length of time, deteriorated rapidly, as shown by the analysis of No. 26.

The percentage of moisture in the cane during the month of October decreased rapidly, and the same quantity by weight of cane yielded only about one-half the weight of juice given earlier in the season. The dryness of the cane was also noted by the farmers, as their loads lost several hundred pounds as compared with the same sized load during the first part of the work. It may also be noted that the cane was very pithy. On an average one out of every five stalks contained little or no juice, and a large amount of fiber. The cane cut during October, a great quantity of which was left lying from two to three days at a time on account of delays in working, did not deteriorate to any great extent. The dryness of the cane again probably explains this.

After the factory stopped, a number of samples of cane was taken for the purpose of determining the condition of the still outstanding crop.

Samples Nos. 382 and 388 gave the highest result of the season. Another sample, No. 383, from a field which the cane-grower claimed was the poorest out, showed a high percentage. No. 378 was from a field of second growth from stubble. On November 4, some 25 tons of cane were left on the rack. One lot was selected and analyzed, some of it put into a silo. A sample of the remainder tested four days later showed that there had been no deterioration in the cane, as can be seen from

analyses Nos. 386 and 391. This cane had been exposed to heavy frost, snow, and thaw.

Cane taken from the field on November 7, and again from same field November 12, showed but little deterioration.

The average percentage of sucrose in the mill juices from the fresh chips is .3 per cent. higher than that recorded in the average of the whole canes. This is explained by noting several very low percentages of sucrose in some of the samples of whole cane, without a corresponding low percentage in the chips.

Here it may be noted that in taking samples of fresh and exhausted chips, as also of diffusion and clarified juices, care was taken to secure comparative samples. The battery consisted of 16 cells, but only 12 of these were in the circuit at one time. The fresh chips were taken from these 12 cells and the exhausted chips from the same. The juices were sampled as they ran into the defecators, care being taken to secure those corresponding to the fresh chips. The samples of semi-sirup were taken as a rule once every twelve hours, and correspond approximately to the juices analyzed. For the most part two sets of samples were taken, one in the morning and the other in the afternoon.

The lowest sucrose and highest glucose were recorded at the beginning of the season. The highest sucrose of the season was noted on October 15, and the lowest glucose on October 26.

The average percentage of sucrose for October was 13.22 and glucose, 2.07. From September 26 to the end of the season the mill juices appeared to be unusually rich. The average for October was .8 per cent. higher than the average for the entire season. This is 2.88 per cent. higher than the average at Fort Scott in 1887. As noted in connection with the whole canes, the dryness may partly explain this, but the location and soil of Conway seem to be especially adapted to the growth of sorghum. It is further south than any other point in Kansas where sorghum has been grown, and the season appears to be longer and better than in eastern Kansas.

The mean of sucrose in diffusion juices is higher than the mean at Fort Scott in 1887, but considerably lower than would be expected from the analyses of the chip juices. The difference may be accounted for either by the dryness and pithiness of the canes, as just mentioned, or by inversion in the battery. In order to prevent inversion, if any, carbonate of lime was used in the battery for a time. Although the acid was neutralized to about the same extent as at Fort Scott, apparently inversion was not prevented. In place of carbonate of lime a number of experiments were made with caustic lime. The lime was distributed upon the chips as they passed from the macerator to the battery by means of a roll, about 1¼ pounds of lime being added to each cell.

The object was to add just so much lime to the chips that 100 c. c. of the juice when in the clarifiers would require about 5 c. c. of $\frac{N}{10}$ alkali to neutralize it.

The highest per cent. of sucrose for the season in the diffusion juice was noted September 29, 10.02 per cent., being 2.30 per cent. above the average. The corresponding mill juice for the same date was 14.92 per cent. sucrose, 2.5 above the average, showing that fair comparative samples had been secured.

The average during October was 8.59 per cent. sucrose, 1.74 per cent. glucose, better than the results obtained at Lawrence, La., bearing in mind the fact that the sugar cane has less glucose. The purity of the diffusion juices was lower than that of the mill juices from the chips. This is due probably to inversion in the battery.

Record was kept during the entire season of the amounts of sucrose and glucose left in the chips. The highest percentage of sucrose in the mill juices from these was noted at the end of the season, November 2, being 2.91 per cent. The average extraction for the entire season was 88.72 per cent. of the sugar in the cane. This is a poor extraction, being fully 4.1 per cent. lower than the extraction at Fort Scott in 1887. The average dilution for the season was 11.55 per cent. From the first of the season to October 15, 160 gallons were drawn off each time; from that date till the close of the season 180 gallons. Each cell held 1,400 pounds chips. Deducting 10 per cent. for fiber we have 1,260 pounds juice in each cell.

Average weight of juice drawn from first of season to October 15 . pounds..	1,349.00
From then till close of season ... do....	1,512.00
Mean Brix from September 6 to October 15:	
In mill juices	18.93
In diffusion juices	13.05
October 15 to Nov. 2:	
Mill juices	20.10
Diffusion juices	12.55
Dilution from September 6 to October 15 ... per cent..	6.50
Dilution from October 15 to close of season ... do....	16.06

The poor extraction was due partly to the large chips furnished by the small cutters during a portion of the season, to the irregularity in working, but chiefly to the small quantity of juice drawn off; all points which might have been more carefully noted and the loss avoided. As the dilution, if moderate, is of small importance, the object should be to get all or as nearly all as possible of the sugar from the cane.

The water from the well proved upon examination to be highly charged with mineral matter, containing 318 grains to the gallon. This was chiefly gypsum, together with some little magnesium sulphate and sodium chloride. A 10-per cent. solution of sugar prepared with this water and evaporated to a thick sirup showed no more inversion than a solution of the same strength made up with distilled water and evaporated. The addition of acetate of lime to the solution had no inverting action.

The water gave particular trouble in the boilers, forming rapidly a heavy scale. The want of proper cleaning in the early part of the season caused burning of the boilers on November 4, and stopped the work. The latter part of the season the vapor water was run into a pond and used for diffusion purposes. This water was strongly acid, due to the decomposition of organic matter, and not much of an improvement on the well water. On account of the foaming it was difficult also to use it in the boilers.

In the few samples of masse cuite not enriched the proportion of sucrose to glucose was about the same as in the semi-sirups, showing that there was not any inversion in the strike pan.

The percentage of ash found in the masse cuite is 1.5 higher, and in the molasses 1 per cent. higher than the average found at Fort Scott in 1887. This we may fairly attribute to the large amount of gypsum in the water. After pond water was substituted for the well water, except on one or two days when lime in the battery was in excess, the corresponding percentage of ash was diminished.

The following is the record of the number of tons of cane worked, sugar and molasses made:

Total number of tons of cane passed over the scales, 2,991.

Of this 430.5 tons were Early Amber mixed with unripe Sterling Orange; 2,560.5 tons were chiefly Orange with a small quantity of Link's Hybrid. The estimated average tonnage per acre is 10. The highest tonnage 13.5 per acre. Twenty-five tons were left on the cane rack when work stopped, so that the actual number of tons of cane worked was 2,966, and tons worked for sugar 2,535.5. Tons of cane for molasses only, 430.5. Deducting 25 per cent. for leaves and seed we have 2,225 tons of cleaned cane.

Total number of cells filled from September 12 to close	2,730
Number of pounds of chips in each cell	1,400
Total number of pounds of chips in cells (1,860 tons)	3,722,000
Number tons cleaned cane from September 12 to close	1,901

Making a difference of 41 tons unaccounted for, some of which was thrown out by the fan and from the drag. The remainder can be attributed to lost records which were missing for several days' work.

YIELD OF SUGAR.

Total number of pounds of sugar	100,500
Gallons of molasses	36,000

There was left on hand at close of season one tank full of semi-sirup, equal to 600 gallons of molasses. This makes average yield of sugar per ton of field cane, estimated on the cane actually worked for sugar, as 39.2 pounds, and on cleaned cane 52.8 pounds per ton. The quantity of molasses made per ton of clean cane was 14. Or estimating the sugar on total number of tons of cane cut during the season we have 45.1 pounds per ton of cleaned cane. Two trial runs were made during the season. The first 46.9, tons, gave 3,986.5 pounds sugar and 9,580 gallons molasses, equal to 85 pounds sugar and 20 gallons molasses per ton. The second trial run gave 90 pounds sugar and 16 gallons of molasses per ton on a run of 60 tons.

During the season there were lost by carelessness 4,800 gallons of semi-sirup and 7,200 gallons of juice, corresponding to about 100 tons of cane. The battery soured twice and was drawn off twenty-eight times, causing a loss of one hundred and ninety-two cells of chips of 1,400 pounds each, equal to 134 tons of cane. Deducting, then, 234 tons from the number of tons worked for sugar we have 1,667 tons of cleaned cane with an average of 60.2 pounds sugar per ton.

From each ton it was estimated that 2 bushels of seed and 200 pounds of leaves were obtained. The seed was carefully hand-picked and thrashed, so that this product will prove very valuable.

The total number of days actual work, counting each day at twenty-two hours, was thirty. By that we mean that the number of hours during which the cutter actually worked would be equal to thirty days of twenty-two hours each. If a factory is substantially built, the machinery strong and every bolt in its place, there is no reason why there should not be a steady yearly run of ninety days full time. During the working season every hour's delay is so much money lost, and a sugar factory should run as smoothly as a grist mill. It is a question of practical mechanics which a good machinist can handle.

ABSTRACT OF THE REPORT OF A. A. DENTON AND C. A. CRAMPTON, STERLING EXPERIMENT STATION.

The experimental work which has been done at the Sterling sugar experiment station was wholly in the line of improving the sorghum plant with a view to increase the yield of sugar from sorghum canes, to obviate certain physical or outward faults of the plant, and to obtain varieties which are less variable in their yield of sugar.

It is probable that the extraction of juice from sorghum canes has nearly or quite reached its practical limit and that diffusion apparatus needs only to be improved in details of construction, which is more properly the work of machinists.

It is probable that the evaporating apparatus used in sugar manufacture, the triple effect, the vacuum pan, etc., will not soon be very greatly improved, for they are the result of many years of experiment by scientists aided by the most skilled engineers.

There remains, however, a very important and promising field for experimental work in the line of sugar manufacture, and that is the improvement of the sorghum plant upon which the sorghum-sugar industry depends for ultimate success. The importance and necessity of such work has been recognized by every one who has been engaged in the development of the industry, but very little has been actually done in that direction; the greatest attention has been devoted to the methods of extraction and manufacture, while the quality of the raw material has been neglected.

If improved varieties of sorghum were developed, as improved varieties of the sugar cane or of the sugar beet have been developed, a successful future for the sorghum-sugar industry in competition with the sugar-cane and the sugar-beet industries could be confidently assured.

In illustration of this disability which hinders the sorghum-sugar industry it is proper to recall the fact that the new beet-sugar factory erected this year in California imported beet seed from Europe at heavy cost, because there the sugar beet has been bred up and improved by many years of persistent effort by experts in that line, so that this European improved beet seed produces at once in California beets which contain from 12 to 15 per cent. of sugar. New sorghum-sugar factories have been built this season in Kansas, but they can nowhere procure similar improved sorghum seed, for the sorghum plant has yet to be developed and improved. As an instance of the necessity for the exercise of care in the selection of seed, the experience of two of the new factories this season may be cited. One of us visited the factories at Douglass and Conway Springs at the beginning of the season, about September 7; at the latter place there was great complaint of the quality of the early cane; seed had been obtained supposed to be pure Early Amber, but seed of later varieties, such as Orange, had been allowed to become mixed with it in considerable quantities, and the result was a field of cane of which the greater part was fully ripe and ready for working while a portion was still green, with the seed not yet out of the dough. It required entirely too much labor to separate it in the field, and when the cane was cut and brought to the factory the green cane lowered the average of the whole to such an extent that it was hardly fit to work for sugar. At Douglass about 100 acres had been planted for early cane with seed supposed to be Early Amber. As the factory was greatly delayed in starting up fears had been entertained that this cane was overripe and deteriorating. Examination showed this "early cane" to be not Early Amber at all, but the old-fashioned Chinese, a variety which, with us at least, did not attain its maximum of sugar content until quite late in the season. Had the factory gotten into operation by the middle of August, as they expected, they would have found their "early cane" entirely too green to make sugar.

THE ORIGIN OF THE EXPERIMENTAL WORK AT THE STERLING SUGAR EXPERIMENT STATION.

In the spring of 1888 the Sterling Sirup Works planted all the varieties of sorghum which, with the time and means at their command, they could procure in this or in

foreign countries, in an experimental field under as similar conditions as possible, in order to enable them to compare the qualities of the canes of the numerous varieties with a view to selecting the best varieties for future cultivation. They had in mind a similar experimental plantation in Jamaica, where 60 to 70 varieties of the sugar cane have for many years been grown in order to select the varieties which were best suited to the West Indies;* the result of which is shown by the fact that an improved variety of sugar cane, which is sometimes called "Jamaica" because it was grown at and introduced by the Jamaica experiment station, is now giving an extraordinary yield of sugar in many places. They were induced to undertake this experimental work by the necessities of their business. In the past seven years they have produced each year from 500 to 700 acres of cane, and have manufactured the crop. Each year they have planted the common varieties, and also varieties new to them which they could readily procure. The selection of better varieties and the improvement of the quality of the canes is a matter of importance to them, as it is to all others who are concerned in the sorghum industry.

It appeared to the Sterling Sirup Works that the first step to be taken in improving the sorghum plant was to collect as many varieties as possible from all localities where sorghum is grown, to acclimate them and practically test the numerous varieties in all the points which constitute a good variety of sorghum.

It is now to be regretted that a much more extended search was not made in this and in foreign countries for other rare and unknown varieties; but they then regarded this year's work as only the beginning of a private research which would continue for some years.

THE NECESSITY FOR IMPROVING THE SORGHUM PLANT.

The sorghum plant is adapted to large areas of the country which are not adapted to the production of sugar from the sugar cane or from the sugar beet. It is especially adapted to the dry climate of the Great West. Its cultivation is suited to the habits of the farming population. When the sorghum plant has been successfully developed and improved as other sugar-producing plants have been, the sorghum-sugar industry will prosper and will employ capital and labor in producing the sugar which we now import.

THE FAULTS OF THE SORGHUM PLANT.

The sorghum plant is sometimes a good sugar-producing plant, sometimes it is merely a sirup-producing plant. This variability in the chemical composition of its juices is what might be expected from a plant which has not yet been bred up to fixed types of excellence by long-continued selections of seed from the finest plants of the best varieties.

In this connection it is interesting to note that in 1744 the chemist Marggraff was able to extract 5 per cent. of sugar from the beet; fifty years afterward the chemist Achard was able to extract but 1 per cent. of sugar from the beet, and the eminent chemist Sir Humphrey Davy published positive assertions that beet sugar could not be made profitably, and that beet sugar was not fit for use. Sixty-five years after Marggraff had extracted 5 per cent. of sugar from the beet, the beet-sugar factories realized only 2 per cent. of sugar from it. These facts seem to indicate that the sugar beet was variable until the plant had been developed.

Besides the variability of the sorghum plant there are other faults which pertain in greater or less degree to the different varieties. Some varieties are long and slender reeds with heavy seed tops and the canes are liable to lodge and tangle in storms. This fault greatly increases the difficulty of harvesting the canes, and the "down" or lodged canes are also inferior in saccharine value.

Some varieties "tiller;" that is, one root produces several canes just as one grain of wheat produces several stalks. This habit is injurious because the secondary canes ripen at different periods, and in harvesting large fields of cane it is impossible to avoid mixing overripe, ripe, and unripe canes. Some varieties have a fault of producing false or secondary seed heads. As soon as the cane approaches maturity, and often before that period, it forms two or more new seed heads which rapidly develop; this delays the ripening of the cane and lessens the yield of sugar. Some varieties, as soon as fully mature, produce offshoots from each joint of the canes and also offshoots from the roots, and the sugar in such rapidly disappears. Some

* Analyses of samples of these different varieties from a collection exhibited at the New Orleans Exposition in 1885 were made by C. A. Crampton, at the sugar laboratory of the Department of Agriculture in its exhibit. The results of these analyses were published by Professor Morris, in the *Jamaica Official Gazette*.

varieties rapidly deteriorate in the quality of the juice as soon as they are ripe and allow little time to manufacture the canes. Some varieties mature very small seeds and these produce plants which are weak and slow-growing in the first weeks of their existence and are kept clear from the more vigorous weeds with greater difficulty than the stronger plants which are produced by the larger seeds.

Some varieties have very impure juice and some have strongly acid juice. Some varieties give light yield of cane, light yield of juice, and light yield of seed. Some varieties obstinately retain the glume or the envelope of the seed grains so that it can not well be separated by ordinary means. Analyses seem to show that the clean grain of sorghum seed is practically equal in value to corn as food for stock, but the adhering glume or envelope contains tannin, which is injurious, and some varieties contain much of this substance and some but little. Some varieties mature so late that they give but little time to manufacture the canes before frost.

THE FAULTS OF THE SORGHUM PLANT AND OF THE SUGAR BEET COMPARED.

The sugar beet contains mineral substance which lessens the yield of sugar. As a rule these mineral substances in the juice vary inversely as the sugar varies; that is, the greater the percentage of sugar the lower the percentage of mineral substance.

Sorghum contains glucose in the juice, and this lessens the yield of sugar. As a rule the percentage of glucose in the juice varies indirectly as the percentage of sugar varies; that is, the greater the percentage of sugar the less the percentage of glucose.

The beet has also physical or outward faults; it is a biennial plant; it stores sugar the first season and produces seed the second season. The sugar beet often goes to seed the first season and such beets are worthless for sugar manufacture.

Sorghum is an annual plant. It produces sugar and also seed in one season; and when it has produced its sugar and its seed it often attempts a second crop of seed, and this lessens the yield of sugar.

The sugar beet sometimes makes a "second growth;" sorghum also sometimes sends out offshoots from every joint and offshoots from the roots. The sugar beet is sometimes hollow; sorghum canes are sometimes pithy and contain but little juice.

The sugar beet is sometimes attacked by the "brown penetration," a discoloration which lessens the yield of sugar; sorghum canes sometimes have brown or red spots in the interior of the canes.

The sugar beet often had faults of form; it had forked roots making harvesting the beets and cleaning them from dirt more difficult; sorghum also has faults of form.

CAN THE SORGHUM PLANT BE IMPROVED?

Judging by all analogies the sorghum plant can be very greatly improved by intelligent and long-continued selection. Stirpiculture in the animal kingdom has given us the Cotswold sheep, the Poland-China hog, the Jersey cow, and the Norman horse. In the vegetable kingdom it has given us the Peabody corn, the Zinfandel grape, the Lapice sugar cane, and the Klein-Wanzleben sugar beet. It has been truly said, "Wherever and whenever plant selection of the best for seed has been long continued wonderful results have been obtained." Darwin said: "Let any common plant, even a roadside weed, for instance, be grown on a large scale and let a sharp-sighted gardener select and propagate slight variations, and see if new varieties do not result." Knauer started with a variety of the sugar beet which contained but 11 per cent. of sugar; he improved it by selecting the best for seed until he produced the "Imperial" variety which contained 16 per cent. of sugar. Deprez et Fils, by selection of seed from the best roots, produced three varieties which contained from from 14 to 16 per cent. of sugar. Vilmorin, the celebrated horticulturist of France, created the "Improved Vilmorin," improved in form and in yield of sugar. There are no apparent reasons why the sorghum plant may not be improved by diligent use of similar methods.

THE METHODS OF IMPROVING THE PLANT.

The principal methods of improving the plant may be stated as follows:

(1) By growing and testing all known varieties and selecting the most promising.
(2) By hybridizing or crossing these varieties.
(3) By preserving "sports" or variations.
(4) By selecting seed from the finest individual canes of each variety.
(5) By improved methods of cultivation.

All of these methods have been practiced to a greater or less extent in the work at this station, and the results will be set forth in the order given above. It must be remembered, however, that the results accomplished in this direction by one season's work can be at best but a mere beginning. To attain the end desired in the improvement of the plant, the continuation of such work over a series of years is indispensable. If this season's work and the methods pursued will serve to point out the necessity and importance of this line of investigation, and, in general, the manner in which it may be best carried out, a great deal will have been accomplished. It is hardly necessary to call attention to the desirability of following up the system of development thus opened up; and it is to be hoped that opportunity may be afforded the Department in the future to carry out this work, which promises to be of the greatest value to the sugar industry.

I. EXPERIMENTS IN GROWING DIFFERENT VARIETIES OF CANE.

It is probable that all varieties of sorghum are not equally well adapted to all localities where sorghum is grown. Some varieties have peculiarities which cause them to succeed best in certain places; the Early Amber, for instance, probably succeeds better and has more valuable qualities in Iowa than in Texas. There is an analogy in this with other plants. A Rhenish variety of the grape succeeds best in dry soil; a Swiss variety succeeds best in wet climates. Spanish varieties of wheat do not succeed in Germany; English wheat does not thrive in India.

To select the best varieties of sorghum for a given locality, it is necessary to grow all known varieties there and to select those which prosper best under its conditions.

It is not now easy to collect seed of numerous varieties of sorghum. The common varieties only are for sale by seed dealers; other varieties can only be found among distant cane-growers in this and in foreign countries. In collecting many varieties many duplicates of some varieties are obtained, because a single variety often has many names. This is natural in foreign countries, where different languages are used; but in our own country the same variety often has many names, which are usually derived from some peculiarity of the plant. This is also true of other plants. It is said that all the varieties of the sugar beet may be classed in four groups. There seem to be twenty-three principal varieties, which have several hundred names.

The varieties of sorghum often can not be distinguished by the appearance of the seed alone, or even by the seed-heads alone; they can best be classed by observing the growing canes. Varieties which have long been grown under very different conditions often vary enough from the usual type to be classed as subvarieties. The Chinese cane from Australia differs in some respects from the Chinese from Central America, and that differs in some respects from the Chinese of this country. These facts add to the difficulty of classifying the numerous varieties of sorghum. Sorghum is also grown in opposite hemispheres, and the proper season to collect varieties of sorghum in one country is not the proper season in another country.

VARIETIES GROWN AT THE STERLING EXPERIMENT STATION.

There were about 250 different plots of sorghum grown at this station. Of these 150 were crosses selected by Mr. Denton; the remaining 100 plots were planted with varieties presumably distinct, though more than one plot was planted of a few standard varieties from seed obtained from different localities. Of those supposed to be distinct varieties, however, though sent in under different names, many were found to be duplicates, showing minor variations perhaps, but not sufficient to entitle them to classification as distinct varieties. For instance, seeds of the well-known variety, the Red Liberian, were received bearing the names "African," "Sumac," "Clubhead," "Rio Blanco," etc.; samples of Honduras seed were named "Honey Cane," "Broom Cane," "Silver Top;" samples of Chinese cane seed were received as "New Sugar Cane" and "Sorghum Saccharatum." It will be seen in the following analyses that seeds of the same varieties received from different localities produced canes of quite different qualities. Thirty-six of the varieties proved to be non-saccharine, useful for forage purposes, but not containing enough saccharine matter to be of value as sugar-producing plants.*

In addition to most of the varieties grown in the United States, the list includes many obtained from Asia, Africa, and South America. The seeds of many foreign varieties were injured by dampness and by insects; from some of these not a single seed germinated.

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*Of the non-saccharine varieties twenty were derived from China, eight from Africa, three from India, and five from this country. The seed from all these were carefully preserved, and will be distributed by the Department. Many will doubtless prove new and valuable acquisitions as forage plants.

COMPARISON OF THE VARIETIES BY ANALYSIS.

It is not an easy matter, as might seem to be the case at first sight, to make a comparison of different varieties by the analysis of juices from selected samples. In the first place, to make a fair comparison between varieties they should be taken at their maximum of maturity, and this is a point which can not be determined by any outward sign, but only by actual analysis. Then the difficulties of sampling cane can only be properly appreciated by one who is familiar with them. Add to these the difficulties of comparison, the obstacles in the way of always getting uniform conditions in the growth of the plots themselves; attacks of chinch-bugs in one plot and not in another; a sandy spot in one and not in another; imperfect germination of seed in one plot, causing a thinstand, while in another plot the canes stand close together; and it will be seen that the task of differentiation between varieties by growing them in plots and submitting the canes produced to analysis, is by no means an easy one. It is a very complex problem. One season's work should never be held conclusive. A variety may have been placed at a disadvantage, from some one of numerous possible causes.

In the work here the varieties were analyzed as often as possible, to avoid the error of having analyses of either unripe or over-ripe canes to compare with the analyses of other varieties at their maximum; the highest analysis obtained may be taken as the basis of comparison. The error of sampling was avoided as much as possible by taking good-sized samples, and by having them all taken by one and the same person.*

The errors arising from differences of growth were augmented, unfortunately, by irregularities in the time of planting, some lots of seed being received very late in the spring. The time of planting is noted with each plot.

In the following table the highest result attained by average samples from plots of the different varieties grown is given. In nearly all cases the sample showing the highest content of sugar gave also the best results in the other two essentials, viz, minimum of glucose and maximum of purity; but where this rule did not hold good the analysis which showed superiority in two essentials was inserted as the maximum analysis attained by the variety during the season.

Table showing maximum analyses of each variety.

Variety.	No. of plot.	Date.	No. of analysis.	Degree Brix.	Sucrose.	Glucose.	Coefficient of purity.
					Per cent.	*Per cent.*	
Swain's Early Golden	93	Aug. 24	3	18.03	12.88	1.92	71.44
Early Tennessee	102	Aug. 24	6	15.54	8.45	2.55	54.38
Whiting's Early Variety	234	Aug. 30	46	15.63	10.30	1.48	65.90
Black Amber	90	Sept. 7	120	12.88	6.50	3.14	50.47
White Amber	92	Aug. 24	....	18.03	12.99	1.84	72.05
Early Amber from New York	23	Aug. 24	4	18.10	13.70	1.12	75.69
Early Amber from Kansas	1	Aug. 25	8	17.54	13.18	1.07	75.14
Folger's Early Variety	249	Oct. 4	460	16.78	11.94	1.46	71.16
Chinese from—							
Central America	62	Oct. 15	593	17.37	11.79	1.35	67.88
New South Wales	215	Sept. 17	216	16.29	9.76	2.25	59.91
Africa	232	Oct. 8	508	17.98	12.46	1.44	69.30
United States	37	Oct. 8	511	19.00	13.23	1.40	69.63
White India	69	Oct. 9	531	17.67	13.07	1.02	73.96
White India from Louisiana	67	Oct. 5	474	16.33	11.90	1.26	72.87
Early Orange from—							
Kansas	84	Sept. 27	371	17.58	12.82	1.33	72.92
South Carolina	228	Oct. 5	467	18.76	13.62	1.72	72.60
Arkansas	87	Sept. 19	270	16.53	11.39	2.20	68.91
Louisiana	68	Sept. 15	601	17.90	12.90	1.13	72.07
Kansas Orange	49	Sept. 9	523	16.91	12.17	1.20	71.97
New Orange	88	Sept. 27	375	16.25	9.53	3.07	58.65
Late Orange from New York	89	Oct. 9	540	17.99	12.73	2.32	70.76
Medium Orange	235	Sept. 26	341	16.70	11.84	1.04	70.90
Red Liberian from—							
Missouri	72	Oct. 4	462	18.80	13.25	2.74	70.48
Texas	73	Sept. 27	367	19.92	14.76	1.84	74.10
Golden Rod	95	Sept. 5	99	14.35	6.96	4.48	48.50
Honey Dew	259	Oct. 22	660	18.10	11.92	2.62	65.86
Dutcher's Hybrid	98	Sept. 3	85	16.24	10.50	2.14	64.66
Link's Hybrid	....	Oct. 5	466	18.45	13.97	.82	75.72

* Mr. Denton did all the sampling himself,

Table showing maximum analyses of each variety—Continued.

Variety.	No. of plot.	Date.	No. of analysis.	Degree Brix.	Sucrose.	Glucose.	Coefficient of purity.
					Per cent.	*Per cent.*	
Price's Hybrid	101	Sept. 3	84	16.84	10.77	2.71	63.95
Planter's Friend	214	Sept. 30	418	20.50	13.83	1.66	67.46
Honduras from—							
Louisiana	64	Oct. 15	595	15.54	9.54	3.24	61.39
Texas	66	Oct. 22	654	15.15	9.84	2.72	64.95
Goose Neck	76	Oct. 22	664	17.20	11.38	2.59	66.16
Waubansee	230	Oct. 5	468	16.32	11.71	.91	71.75
White African	229	Sept. 22	305	17.20	11.10	1.67	64.54
Texas Red	....	Oct. 10	545	20.25	13.80	2.84	68.14
Unnamed varieties—							
United States	9	Oct. 15	610	16.26	11.48	1.29	70.60
South Africa	11	Oct. 8	513	12.20	6.55	2.65	53.69
United States	14	Oct. 19	646	18.60	13.84	.55	74.41
India	15	Sept. 26	347	18.64	12.87	.60	69.05
South Africa	16	Oct. 19	644	16.10	10.70	1.31	66.46
United States	22	Oct. 19	648	17.09	11.54	1.49	67.52
Africa	24	Oct. 6	497	18.42	12.72	2.86	69.06
Do	26	Oct. 8	515	16.31	11.48	1.60	70.39
Do	28	Oct. 15	608	16.20	11.38	1.41	70.25
United States	33	Sept. 26	351	16.97	11.85	1.41	69.83
Africa	36	Oct. 6	494	15.32	10.29	.63	67.17
Do	39	Oct. 5	480	17.20	12.79	.60	74.36
United States	44	Sept. 26	356	17.44	11.87	1.05	68.06
Do	50	Oct. 9	524	18.00	13.28	1.01	73.78
Do	51	Oct. 6	498	17.77	12.80	2.27	72.03
Do	53	Oct. 6	490	16.85	10.57	2.96	62.73
Do	57	Oct. 19	634	18.00	9.93	3.50	55.17
Do	61	Oct. 19	636	18.60	13.06	2.32	70.22
Average	....	....	....	16.79	11.69	1.85	69.62

These results are quite interesting as furnishing a means of comparison of the relative merits of the different varieties. The ten varieties which stand highest in each of the three essentials are given below, in the order of their value:

List of ten varieties giving best results.

No.	Sucrose.	Per cent.	Glucose.	Per cent.	Coefficient of purity.	Per cent.
1	Red Liberian	14.76	Plot No. 14, U. S	.55	Link's Hybrid	75.72
2	Link's Hybrid	13.97	Plot No. 39, Africa	.60	Early Amber	75.69
3	Plot No. 14	13.84	Plot No. 36, Africa	.63	Plot No. 14	74.41
4	Planter's Friend	13.83	Plot No. 15, India	.65	Plot No. 39	74.36
5	Texas Red	13.80	Link's Hybrid	.82	Red Liberian	74.10
6	Early Amber	13.70	Waubansee	.91	White India	73.96
7	Early Orange	13.62	Plot No. 50	1.01	Plot No. 50	73.78
8	Plot No. 50	13.28	White India	1.02	Early Orange	72.92
9	Chinese	13.23	Medium Orange	1.04	Plot No. 51	72.03
10	White India	13.07	Plot No. 44, U. S	1.05	Kansas Orange	71.97

These lists comprehend altogether eighteen varieties, of which four appear in all three of the lists, four on two, and ten on only one, as follows:

Plot No. 14	3	Plot No. 15	1
Link's Hybrid	3	Waubansee	1
Plot No. 50	3	Medium Orange	1
White India	3	Plot No. 44	1
Plot No. 39	2	Plot No. 51	1
Early Amber	2	Kansas Orange	1
Red Liberian	2	Planter's Friend	1
Early Orange	2	Texas Red	1
Plot No. 36	1	Chinese	1

From this it will be seen that four varieties combine in a high degree the three good qualities of a large percentage of sucrose, low content of glucose, and high purity of juice. Link's Hybrid and the unnamed variety No. 14 divide honors for the first place, both standing very near the top of the list in all three essentials. The former has always proved a good sugar producer, where it has had time to mature before frost. The Early Amber is noticeable for its high purity, five of the plots of its sub-varieties giving a purity of over 70; from this quality doubtless arises its superiority as a sirup-making variety. The low content of glucose in several of the unnamed varieties from tropical countries is remarkable, as most of them were not entirely mature before frost. It must not be lost sight of in comparing the varieties on the basis of the analysis that the outward faults of a variety may entirely overbalance its value as shown by analysis. The Link's Hybrid, for instance, which gives such good results on analysis, has a fault of form that almost destroys its practical value.

II. Experiments in Hybridizing or Crossing Varieties.—III. Experiments in Preserving Sports or Variations.

These two methods of improvement may as well be considered together, for in the present condition of the sorghum plant it is hard to draw the line between them. The different varieties which have become established cross so readily with one another that where variations occur, in a field of cane, for instance, it is often difficult to say positively whether it is a true sport, whether it is from one seed of a distinct variety accidentally introduced, or whether it is from a seed that had been cross-fertilized from a different variety. Doubtless both causes of variation obtain to a large extent, for the one is a natural consequence of the other; that is, on account of the readiness with which two individuals cross, a large number of varieties have been produced, and, as many of these are not well established or fixed, they exhibit a constant tendency to revert to original types, thus showing variations. Whether the wide variations shown in the different kinds of sorghum are due more to crossing or more to type variation is a question it is unnecessary to discuss here. It is sufficient to show that such capability for variation does exist. In the work done at this station no distinction could be made between variations produced by crossing and those which were true sports. As this season's work was only the beginning it was impossible to obtain true artificially-produced crosses, that is, variations produced by the careful cross-fertilization of two distinct and definite types. The plots called "crosses" were planted from seed heads obtained by Mr. Denton from various fields of sorghum, and were simply variations from the general type of the cane growing about them. In the great majority of these cases, the canes produced from this seed showed such well-marked reversions to two well-defined types that it was a pretty fair presumption that they actually did result from the cross-fertilization of those types; but of course such work should, in the future, be carried out upon known types, artificially cross-fertilized.

GENERAL OBSERVATIONS ON CROSSES.

Kolreuter says: "He who would produce new varieties should cross varieties." Darwin says: "In regard to the beneficial effect of crosses between varieties there is plenty of evidence." "The crossing of two forms which have long been cultivated implies that new characters actually arise some of which may be valuable and permanent." It would be superfluous to quote more, for Gartner, Herbert, Sageret, Lecoq, Naudin, and many other eminent experimenters speak of the wonderful vigor, size, tenacity of life, precocity, and hardiness of hybrid productions.

It is stated in "The Sugar Beet"* that "if a superior variety of beets be placed near another variety the result will be most advantageous, and it may be concluded from these experiments which we indorse that the resulting race will for the time being be richer in seed, and that the roots grown therefrom will contain a sugar content more regular, etc., than had existed in either."

In regard to the effect of crossing varieties it can be said that it seems to increase the vigor of the plants sometimes in a wonderful degree. The crossed canes are often much larger and taller, and often have much heavier seed heads than either parent form. A crossed cane is sometimes earlier, often later in maturing than either parent. Some crosses breed true to the new type from the start and show no tendency to reversion; but usually the first season the crossed seeds are planted some of the plants revert, some to one parent form, some to the other, and some are

* "The Sugar Beet," by Lewis E. Ware.

intermediate forms. If now seed of the type preferred is selected and planted again the new plants show less tendency to revert; by continuing the selection and throwing out varying forms, the new type is fixed and becomes a new variety. There is greater tendency to reversion in "violent" crosses between dissimilar forms than in crosses of allied forms. A cross may be slight or complete, in fact, there may be several crosses between two varieties. For instance, a fixed cross between the Early Amber and the Orange may resemble the Early Amber more; another cross between the same varieties may resemble the Orange more. Three canes taken from a plot of this last cross showed by analysis a higher percentage of sugar than any other in the season's work, with one exception.

ADVANTAGES OF SORGHUM OVER SUGAR CANE ON ACCOUNT OF THE EASE WITH WHICH VARIATIONS ARE PRODUCED IN THE FORMER.

Dr. Morris, formerly director of the Jamaica Botanical Gardens, where an experimental plantation of sixty to seventy varieties of the sugar cane is maintained, in an address before the London Chamber of Commerce said:

"It is well known that the sugar cane does not produce seed, and hence it is impossible to improve it by any process of hybridizing and crossing found so beneficial to other plants. New varieties amongst sugar canes arise generally in the form of bud variation. These occur very seldom, and possibly amongst thousands of acres not one cane will be detected which exhibits any well-marked characteristics. Planters, however, should be keen to notice any canes that show a departure from the types and should cultivate them separately. If the sugar cane were capable of being improved purely by cultivation and experimental processes like those which have improved the beet, this would be one of the most effective means of benefiting the industry."

GENERAL OBSERVATIONS ON "SPORTS" OR SPONTANEOUS VARIATIONS.

It is well known that new varieties sometimes suddenly and spontaneously appear in plants. They are created by bud variation. A peach tree suddenly produces a branch which yields nectarines. A plum tree which had yielded yellow plums for forty years produced a single bud which produced a new and valuable permanent variety, the red Magnum Bonum plum. The variations in the tropical sugar cane were entirely produced in that way, as has already been shown by the statements of Professor Morris, just quoted. In Mauritius a sugar cane of the ribbon variety produced two new canes, a green cane and a red one. This was considered an astonishing variation there. The causes of such variations are unknown. It is only known that they do occur, and that valuable new varieties sometimes suddenly appear. The history of some of the varieties of sorghum would seem to indicate, so far as it is possible to obtain accurate information of such matters, that they originated in this way. In Indiana, in a field of Chinese cane, a single cane ripened two weeks earlier than the other canes; this variation was preserved and named the Early Amber. It is the most widely known of all the varieties of sorghum. In the experimental field of this station there were growing Early Amber canes received from New South Wales, from Cape Town, and from many places, showing its wide distribution.

In New York in a field of Early Amber only one cane ripened before frost. This variation was preserved and named by us Whiting's Early Variety. It matures ten days earlier than the Early Amber. It seems to be a sport from a sport.

In Tennessee, in a field of Honduras a single cane ripened two weeks earlier than the other canes. This variation was preserved and was named Link's Hybrid. It is one of the best varieties of sorghum for sugar manufacture. It has been known to have as high as 19.25 per cent. of cane sugar in its juice by analysis.

WORK AT THE STERLING STATION ON CROSSES OR VARIATIONS.

It may be said of the work done here in this direction that, in the first place, it established positively, in the judgment of those in charge, *the fact of the very strong tendency of this plant towards variability.* This fact has, of course, been frequently noticed and commented upon heretofore, but as it seems very essential that it should be thoroughly and generally understood, we think it advisable to enter into an exposition of the evidence that was obtained to justify us in coming to the very decided conclusion we adopted upon this point. The plots which were planted as "crosses" at this station were in every case from single seed heads, selected by

Mr. Denton, and which were very carefully cleaned and thrashed, special precautions being taken to prevent any accidental mixture of seed from other sources. These plots were then, in every case, the product of a *single head*. They showed, in the majority of cases, the greatest variation among the individual canes.

This variability is well shown by a series of photographs taken by us, which were intended to be reproduced as illustrations of this report; unfortunately the fund provided for such illustrations was exhausted so that they had to be omitted. They represent a number of seed heads, all taken from the *same plot*, which showed striking variations from either parent type, as well as gradations running back to each. In a plot planted from a single seed head which was evidently a cross between the Orange and India, for instance, heads were selected which gave the greatest variations and gradations between the India type, with its white seeds and rather loose head, to the Orange, with its reddish-colored seeds and compact head. Another represents the range of variations between the Honduras and Red Liberian, two widely different varieties, with the small round seed of the Liberian type set closely on the sprangle top head of the Honduras. These photographs of the widely different types produced from a *single seed head* would convince the most skeptical of the great ease with which variations can be produced in sorghum.

LIST OF CROSSES.

The following list gives the number of the experimental plot with the probable parents of some of the crosses grown this season. Many plots are not included, as the characters shown by the canes did not distinctly indicate the origin of the variations.

No of plot.	Probable cross.	No. of plot.	Probable cross.
110	New Orange and Early Orange.	163	India and Orange.
111	Chinese and Liberian.	165	India and Amber.
112	Kansas Orange and Amber.	166	Do.
114	Golden Rod Cross.	167	India Cross.
115	Orange and Amber.	168	Do.
117	Kansas Orange and Amber.	171	Kansas Orange and India.
118	Liberian and Golden Rod.	172	New Orange Cross.
120	Amber and Kansas Orange.	173	India Cross.
121	Orange and White India.	174	India and Amber.
122	Orange and Chinese.	175	New Orange and Early Orange.
124	India Cross.	176	Orange Cross.
127	Do.	178	India and Orange.
128	India and Golden Rod.	179	India Cross.
129	Do.	180	Orange and India.
131	Orange and India.	181	Do.
132	India and Golden Rod.	182	India and Amber.
133	Kansas Orange and India.	183	India Cross.
134	Orange and Golden Rod.	184	Orange and India.
135	Early Orange and Amber.	185	Orange Cross.
136	Orange and India.	186	Orange and India.
137	India and Amber.	187	Do.
138	Do.	188	Do.
139	Orange and India.	193	Orange Cross.
140	Do.	194	Do.
142	India Cross.	195	Orange and India.
144	Orange and Amber.	196	Kansas Orange and India.
146	Kansas Orange and Golden Rod.	197	India Cross.
147	Do.	200	New Orange Cross.
151	Orange and India.	201	Do.
153	Kansas Orange and Early Amber.	202	India Cross.
154	Amber and New Orange.	204	India and Orange.
155	Orange Cross.	205	Orange Cross.
157	Amber Cross.	208	India Cross.
158	India and Orange.	211	Orange and India.
161	Kansas Orange and India.	212	Do.
162	India and Orange.		

ANALYSES OF THE CROSSES.

The following tables give only the selected analyses of single canes from the crosses. They represent about 700 analyses, only those containing the highest percentage of sugar, together with outward characters which entitled them to perpetuation, having been subjected to complete analysis.

Plots Nos. 153 and 184 gave probably the best results.

Analyses of single canes from Crosses.

No. of plot.	Date.	No. of analysis.	Degree Brix.	Sucrose.	Glucose.	Coefficient of purity.
				Per cent.	*Per cent.*	
109.....	Sept. 24	463	16.54	10.31	2.31	62.33
113.....	Oct. 10	1070	18.00	13.24	1.16	73.56
123...	Sept. 24	469	17.00	11.37	1.12	66.88
	Sept. 28	531	17.20	11.33	1.73	65.87
128.....	Oct. 10	1050	18.50	13.81	1.20	74.65
130.....	Oct. 10	1042	20.48	15.20	1.09	74.21
131...	Sept. 28	561	19.37	14.39	1.18	74.29
	Oct. 10	1059	20.00	14.48	2.03	72.40
132.....	Sept. 28	562	19.42	13.52	1.65	69.62
133.....	Oct. 11	1229	20.65	15.03	1.93	72.78
135...	Sept. 29	574	20.37	14.01	1.29	69.21
	Oct. 11	1218	21.18	16.33	.77	77.28
137...	Sept. 29	585	20.20	15.32	1.21	75.84
	Sept. 29	586	21.50	16.26	.81	75.63
138.....	Sept. 29	590	17.78	13.45	.69	75.65
142...	Sept. 29	613	20.78	15.54	2.33	74.78
	Oct. 10	1104	20.07	14.95	1.98	74.49
144.....	Sept. 29	621	19.28	14.68	1.10	76.14
146.....	Sept. 29	625	19.28	13.91	1.82	72.15
147.....	Sept. 29	603	15.87	11.61	1.69	73.16
148.....	Sept. 29	611	20.88	15.78	1.63	75.57
151.....	Oct. 11	1242	21.33	14.75	1.57	69.15
153...	Oct. 1	652	22.50	17.18	.58	76.36
	Oct. 11	1134	22.50	16.85	.91	74.89
155.....	Oct. 1	660	20.09	14.27	1.06	71.03
156.....	Oct. 1	664	18.62	12.15	4.56	65.25
159.....	Oct. 1	673	17.65	12.49	1.45	70.76
161...	Oct. 11	1277	20.70	15.40	.80	74.40
	Oct. 11	1287	19.70	14.89	.81	75.58
162.....	Oct. 1	691	18.85	13.84	1.24	73.42
163.....	Oct. 1	706	20.47	15.53	1.30	75.87
165...	Oct. 1	711	19.47	14.52	.53	74.58
	Oct. 12	1332	19.42	14.35	.69	73.89
166.....	Oct. 13	1491	19.78	15.04	.75	76.04
168.....	Oct. 1	738	18.60	14.98	.75	80.54
173...	Oct. 2	753	20.30	14.44	1.53	71.13
	Oct. 10	1067	21.20	14.28	1.90	67.36
	Oct. 12	1433	21.70	16.29	1.19	75.07
174...	Oct. 2	762	18.43	13.25	2.02	71.89
	Oct. 12	1412	21.60	14.86	2.65	68.80
175.....	Oct. 2	769	18.20	12.11	2.82	66.54
176.....	Oct. 2	776	19.93	14.81	1.76	74.31
178.....	Oct. 2	780	19.50	14.32	1.29	73.44
180.....	Oct. 3	811	20.00	14.14	1.05	70.70
182.....	Oct. 12	1357	20.28	13.96	1.53	68.84
184.....	Oct. 12	1344	21.78	16.40	1.01	75.30
208.....	Oct. 2	840	19.00	12.99	1.28	68.37
209.....	Oct. 2	833	20.03	14.43	1.17	71.99
212.....	Oct. 2	830	19.63	14.84	1.38	75.60
238.....	Oct. 9	1028	17.48	13.14	2.07	75.17
239...	Oct. 5	984	19.50	14.65	1.04	75.13
	Oct. 8	1010	20.14	15.24	1.55	75.67
	Oct. 8	1012	19.84	15.17	2.23	76.46

ANALYSES OF VARIATIONS IN STANDARD VARIETIES.

The following table gives some of the results of analyses of individual canes which were taken from the plots of some standard varieties, and which showed some *desirable* variation from the type of the variety. The variations chosen were in the line of the improvement of the variety. For example, the variations selected from the Honduras were individuals which ripened earlier than the rest of the plot; those of the Link's Hybrid were canes which showed more or less freedom from the faults of the variety. As with the crosses, the analyses given are the chosen ones of a large number of analyses, for none of the canes which showed simply an improvement in external characters were saved, unless they showed at the same time a good content of sugar and a high coefficient of purity. These will be reserved for planting another season.

Analyses of variations in standard varieties.

No. of plot.	Date.	No. of analysis.	Degree Brix.	Sucrose.	Glucose.	Coefficient of purity.	Remarks.
				Per cent.	Per cent.		
225-6.	Sept. 3	263	14.43	9.07	1.83	62.38	Honduras.
	Sept. 3	266	13.53	8.46	2.37	62.53	
	Sept. 17	306	17.84	12.14	.79	68.05	
	Sept. 17	313	18.72	12.59	1.18	67.25	
	Sept. 17	316	18.33	12.28	2.74	66.99	
	Sept. 20	338	18.28	12.70	2.65	69.47	
	Oct. 20	2118	20.00	14.90	1.02	74.50	
230...	Sept. 21	340	18.32	13.04	.99	71.18	Waubansee.
	Sept. 21	341	17.52	12.07	.81	68.89	
	Sept. 21	393	15.35	9.58	1.13	62.41	
234.....	Sept. 25	478	18.13	13.96	.91	77.00	Whiting's Early.
89......	Sept. 25	500	18.78	13.64	2.94	72.63	Late Orange.
68......	Sept. 28	521	17.21	14.42	.76	83.79	Early Orange.
67......	Oct. 3	893	19.20	14.04	1.37	73.13	White Mammoth.
232.....	Oct. 3	911	19.08	14.79	1.06	77.52	Chinese.
	Oct. 3	949	22.31	16.93	.55	75.89	Link's.

The unnamed plots also contained a great many interesting variations, selections from which are given in the following table:

Analyses of variations in the unnamed varieties.

No. of plot.	Date.	No. of analysis.	Degree Brix.	Sucrose.	Glucose.	Coefficient of purity.
				Per cent.	Per cent.	
9.......	Sept. 24	428	18.67	13.84	.80	74.13
33......	Sept. 25	509	19.48	13.17	2.61	67.61
37......	Sept. 22	396	19.60	14.26	1.04	72.76
45....	Sept. 22	406	19.60	13.92	.44	71.02
	Sept. 22	410	20.74	14.86	.37	71.65
46....	Sept. 21	360	20.60	14.83	.70	71.99
	Sept. 21	364	19.62	13.47	1.54	68.65
	Sept. 21	365	20.19	14.79	.76	73.25
	Sept. 21	366	20.75	15.14	.77	72.96
	Sept. 21	372	19.15	13.74	.59	71.75
	Sept. 21	373	19.92	14.67	.64	73.64
	Sept. 21	374	19.35	13.68	1.07	70.70
48....	Sept. 21	377	20.78	14.27	2.09	68.67
	Sept. 25	514	18.31	12.36	2.30	67.50
50....	Sept. 4	290	18.44	13.25	1.01	71.85
	Sept. 24	444	18.48	13.57	.95	73.43

IV. Experiments in the Selection of Seed from Individual Canes Showing a High Content of Sugar.

VARIABILITY OF SORGHUM CANES IN THEIR CONTENT OF SUGAR.

As might be expected of a plant which varies so much in the outward characters of its individuals, sorghum canes vary greatly in the chemical composition of their contained juices. Even in canes of the same varieties, showing uniform outward characters, and of uniform appearance and development, great differences will be found in the composition of the juice from individual canes; in fact, the variation in this respect seems much greater and more persistent than in the outward appearances of the plant. When the variety itself is not uniform, and the variations due to mixed races are added to the variations of the individuals, the most remarkable extremes are produced. This can be seen by examining the analyses of individual canes of crosses given in the section on experiments with crosses, from which the following table is selected to illustrate the possible differences between different

canes growing in the same plot. The canes were selected from a plot of Honduras which showed fairly uniform character, in the endeavor to obtain early ripened seeds of that variety, and probably some were not matured so well as others, though the seed from all was perfectly hard.

Polarization of selected canes from Honduras.

No.	Degree Brix.	Sucrose.
		Per cent.
1......	6.93	.20
2......	14.43	9.07
3......	13.53	8.46
4......	13.47	8.16
5......	10.47	4.31
6......	14.40	7.40
7......	11.85	5.78
8......	10.04	1.51
9	11.65	5.24
10......	....	.10
11......	14.15	8.25
12......	17.05	11.41
13......	15.88	10.92
14......	15.34	9.33
15......	15.34	7.51
16......	15.54	6.50
17......	16.67	11.53
Highest............		11.53
Lowest.............		.10

The following table shows the variation of individuals in a well-established and uniform variety. They were selected with this end in view from a remarkably uniform plot of Early Amber, and a particular effort was made to have the canes as nearly of the same size and general appearance, the same maturity, and the same conditions of growth as possible. All were taken from the same row.

Polarization of average canes from Early Amber.

No.	Degree Brix.	Sucrose.
		Per cent.
1.....	15.50	10.80
2......	15.70	12.02
3......	14.50	7.54
4......	18.00	12.78
5......	16.74	10.36
6......	14.74	8.58
7......	15.44	9.58
8......	18.44	13.25
9......	17.24	11.61
10......	17.44	11.99
11......	14.24	8.08
12......	17.74	12.71
13......	17.52	12.04
14......	17.32	10.53
15......	17.32	10.88
Highest		13.25
Lowest		7.54

While the difference is not so great as in the previous table it will be seen that there is a difference of nearly 6 per cent. of sucrose between the richest and poorest canes in fifteen samples.

DIFFICULTIES IN THE SELECTION OF SEED ACCORDING TO CONTENT OF SUGAR IN THE CANE.

It is much more difficult to select the best individuals of a sugar-producing plant than of plants raised for other purposes in which the relative merit of the individuals can be seen by outward appearances. There are no known reliable outward signs which indicate that a certain cano contains more sugar than the others. In a garden

one can select the finest vegetables, in the orchard the finest fruits, in the grain fields the finest ears of corn or of wheat either by the eye or by the weight or by very simple tests; but sugar is inside the canes, mingled with other substances. The weight of the canes or their appearance is not a reliable measure of the sugar which they contain. Handsome canes may contain but little sugar; canes inferior in appearance may yield sugar well. The sense of taste is not a reliable test, for the sugar in the juice is masked by other substances. A sugar cane which shows by analysis 12 per cent. of sugar tastes much sweeter than a sorghum cane which shows 15 per cent. The sorghum plant will be improved but slowly if selections of seed are made only by the size or weight or appearance of the canes, or by simple selections of the finest appearing seeds.

In two thousand analyses and polarizations of cane juice made at this station there were no reliable and constant outward marks observed by which the canes which contained most sugar could be selected. The degree of maturity was the only sign, and selections of the richest canes can not be made by that.

When the sugar-beet growers attempted to improve the sugar beet they met with the same difficulty. They were well aware that the hereditary principles which are known to apply to animals also apply to plants. They knew that the individual beets which actually contained more sugar than the others should be saved for planting.

But the characteristic points of beets which are rich in sugar vary so that they are not reliable guides in selecting beets for seed. Knauer invented a machine which separated beets into piles according to their weight in order to select the heaviest, not the largest, beets for seed. And beets were placed in a solution of salt water of a certain density; the beets which sank were saved for seed. These methods were not reliable. To Vilmorin is due the credit of introducing the methods by which the sugar beet has been so wonderfully improved. He observed that a cylindrical piece could be taken from each beet without injury to the plant. These sample pieces were separately tested to determine their value in sugar manufacture, and only the beets which were proved to contain more sugar than the others were saved for seed. To show the zeal with which the work of improving the sugar beet was done it is only necessary to say that at the Paris Exposition of 1878 there were twenty exhibitors who claimed to have produced improved varieties of the beet. Deprez et Fils, of France, had an agricultural laboratory with facilities for making two thousand analyses of beets daily. With the assistance of Professor Violette they produced three important new varieties of the sugar beet, which are known as "Improved Deprez" 1, 2, and 3.

It is evident that the sorghum industry should profit by this experience of the beet industry, and that sorghum seed should be saved only from individual canes which yield well in sugar.

METHOD OF WORK EMPLOYED AT THE STERLING EXPERIMENT STATION.

Owing to the pressure of work at this station the past campaign, and the attention given the crosses, the selection of seed from the best individual canes of the established varieties was not instituted until late in the season, and could not be carried out on the earlier varieties; the selections should properly be made, of course, at the maximum of maturity of the cane. The plan of work was as follows: A large number of canes were selected from the plot, care being taken that those selected should show no outward faults of form, and should be average canes in size and of good healthy appearance. A large number of such canes were brought into the station barn and laid out in serial order, the heads cut off, a label with number attached to each, and a corresponding number placed on a receptacle to contain the juice. Two men were kept busy turning the hand-mill, while a third kept the juices in proper order. As soon as the juices were obtained they were poured into hydrometer jars, and when they had stood long enough to permit of the escape of the air bubbles, their density was taken roughly with a spindle. If the reading did not come up to a certain standard, the juices and corresponding seed heads were rejected. The standard used depended upon the richness of the variety of cane from which the selections were made, being placed at 20° or even 21° Brix for very rich varieties like the Link's Hybrid. The few juices which passed the test were sent to the laboratory for complete analysis, and the corresponding seed heads carefully preserved. From the complete analyses, still further selections were made, so that ultimately a few seed heads were saved, showing great richness and purity of juice. From 500 to 1,000 canes could be tested in this way in a day. Some of the canes obtained by this method of selection were very rich in sugar. The following instances serve to show this:

A plot of Link's Hybrid, of which the highest analysis from average samples had

been 14.09 per cent. sucrose, gave by selection from about 500 canes four which went over 15 per cent. Another plot of the same variety, showing by analysis of an average sample 12.24 per cent. sucrose, gave by selection from 500 canes three which had over 16 per cent. sucrose in the juice. An average sample of a plot of Liberian cane gave 14 per cent.; 500 canes were taken from different parts of the plot, and one cane gave 17.59 per cent. sucrose in the juice, three gave over 16.5 per cent., and twelve over 15.5 per cent. An average sample of the Planter's Friend, a new variety from Australia, gave 11.63 per cent. sucrose; selections from 1,000 canes gave three which contained over 15 per cent. sucrose in the juice. Such instances might be multiplied, but sufficient evidence has been given to show the possibilities in this method of improvement. The selections have all been preserved, and can be planted and observed another year if means are afforded the Department for carrying out the work.

The following table gives the highest analyses obtained in each of five varieties by selection:

Highest analyses of single canes by selection from standard varieties.

Variety.	Date.	No. of analysis.	Degree Brix.	Sucrose.	Glucose.	Coefficient of purity.
				Per cent.	*Per cent.*	
Liberian	Oct. 17	1953	21.71	17.69	1.97	81.48
Early Orange	Oct. 18	2040	22.18	17.05	.67	76.87
Link's Hybrid	Oct. 18	2036	21.70	15.92	.69	75.38
Planter's Friend	Oct. 16	1831	22.00	15.55	.82	70.68
Chinese	Oct. 13	1508	19.68	14.71	1.25	74.75

V. Experiments in Improvement by Methods of Cultivation.

It is a rule in agricultural science that to obtain the best results the individual plants must be given the most favorable conditions possible for full development. In the effort to improve the sorghum plant methods of cultivation will play an important part. Very little attention has been paid heretofore to this subject, the cheapest and easiest methods being followed, and the sorghum crop has had about the same cultivation as is given to the corn crop. In the work at this station no very extensive experiments could be made on different methods of cultivation, but a number of practical points were evolved which may be stated as our views on the best methods to be followed without going into details as to the evidence upon which the conclusions were based.

It is desirable in growing cane for sugar manufacture that as nearly as possible all of the plants in one field should ripen at one time. If in one row there are some canes fully ripe and other canes immature, it will not be easy to harvest the canes at the time when each contains its maximum of sugar. It is a point of advantage to have all come up at the same time. This can best be accomplished by planting the cane on freshly-plowed land the same day the land is plowed and by being careful to cover the cane seed at a uniform depth with earth. This insures as uniform a start as possible for the canes, and while it may seem a trifling matter, it often materially affects the result.

After the young plants come up a serious problem arises, and that is, how to cultivate the plants, to pulverize and loosen the soil, and to destroy the weeds without injuring the roots on which the development of the plants depends. Great injury is done to the roots of canes when the cultivator works deep and close to the plants after they have attained considerable size. This injury is perhaps greater than most persons suppose. It appears to be proved by a very simple experiment. If the roots of a hill of cane are cut all around the hill with a spade at a distance of 6 inches from the canes to a depth of 6 inches from the surface when the plants are 4 inches high, and if this process is repeated once a week until the canes are 4 feet high, the canes thus treated will be found to ripen later and to be inferior in all respects. In wet seasons the injury is not so great as in dry, but injuries are caused to growing plants by the cultivator as with the spade.

To avoid destroying and mutilating the roots of growing canes it seems better to give deep and close cultivation while the plants and their roots are small, and when the first cultivation is given to use long and narrow shovels which work near the canes, and with a slow and steady team give close and deep and thorough cultivation before the rootlets are expanded sufficiently to be injured by such cultivation.

In the succeeding cultivations "shallow shovels," that is, shovels having such form that they do their work at and near the surface of the soil, should work near the plants, while deeper cultivation may be had at a distance from the plants which the roots have not reached. The form preferred in the experiments at this station is known as the "Eagle's Claw." It consists of eight small shovels which are attached to the beams of a two-horse cultivator, four shovels working on each side of the row of cane. The form of these shovels is such that they do not enter the soil deeply, they thoroughly pulverize all the surface soil and destroy weeds, and work close to the growing plants with little injury to the roots.

We have alluded to these points because we believe the yield of sugar is often materially lessened by injuring the roots of the canes. Mutilation of the cane plants above the surface of the soil is known to produce a lessened yield of sugar, and injuries to the cane plants below the surface doubtless decrease it also. Many cane growers as they "lay by" their cane crop or finish the cultivation, and see its deeply and closely cultivated canes free from weeds do not realize that while destroying the weeds they nearly destroyed their cane plants, and while working *for* their canes they were really working *against* them and against their yield of sugar.

VI. Miscellaneous Experiments and Results of Observations.

ANALYSES OF SAMPLES FROM ARKANSAS.

The capabilities of Arkansas as a sorghum-growing State have never been very extensively investigated. The Sterling Sirup Works received this fall a bundle of cane from one of the "prairie counties" of Arkansas, and the different samples were analyzed at the station with the following results:

Analyses of cane from Arkansas, sent to Sterling Sirup Works.

Variety.	No. of analysis.	Degree Brix.	Sucrose.	Glucose.	Coefficient of purity.
			Per cent.	*Per cent.*	
Texas Red	545	20.25	13.80	2.84	68.1
Honduras	546	20.25	3.68	8.47	18.
Chinese	547	18.25	11.05	5.24	61.
Orange	548	19.25	14.24	2.23	74.

As a general rule samples of sorghum sent from one point to another by express are so much inverted that the analyses are worthless; and then when samples of a few canes are selected by persons not familiar with the plant, the largest and finest looking canes are chosen, which generally give a lower per cent. of sugar than average-sized canes. In view of these facts the above analyses make a remarkably fine showing for the locality which produced the canes; the samples all consisted of quite large, fine canes, but still gave a good analysis. The sample of Texas Red was a tremendously large cane. The samples of Honduras and Chinese had evidently inverted slightly, the others very little.

Another lot of samples received by the sirup works from Thomas Lester, Stuttgart, Ark., consisted of the following varieties: Gooseneck, Honduras, and Orange. As the analysis showed all to be badly inverted, it is not worth while to give the results.

PROGRESS OF THE BEET-SUGAR INDUSTRY.

The interest in the manufacture of sugar from the sugar beet in this country is constantly increasing.

During the past season the Department distributed quite a quantity of sugar-beet seed to various parts of the country, and a number of samples grown by farmers in different localities has been sent to Washington for examination. The culture of the sugar beet has extended in the State of California, and in addition to the factory operated at Alvarado, the reports of which have been published in previous documents, a large factory has been established by Mr. Claus Spreckels and others at Watsonville, Cal. The corporation is known as the Western Beet Sugar Company, and has a capital stock of $500,000. The operations of the first year were very successful, and through the kindness of Mr. Spreckels I am enabled to

append a statement giving the résumé of the work done, expenses incurred, and amount and value of sugar made:

Recapitulation of the workings of the Western Beet Sugar Company's factory at Watsonville, Santa Cruz County, Cal., for the campaign ending December 19, 1888.

Sugar, freight from Watsonville to San Francisco		$2,936.55
Coal	total cost	17,267.00
Coke	do	1,658.93
Fuel oil	do	11,356.02
Wood	do	990.50
Lime rock	do	1,780.30
Sugar bags	do	1,740.34
Soda	do	12.39
Tallow	do	57.21
Expense labor, etc		21,091.27
(Beets) incidentals		2,575.82
Cost of beets		71,055.89
		132,522.22
Which is the cost of manufacturing 1,640 tons sugar delivered free on board in San Francisco.		
We have received for 3,280,000 pounds sugar		162,454.70
Making cost of sugar $80.80 per ton of 2,000 pounds.		
Profit		29,932.48

Beets consumed	tons	14,077
Sugar produced	do	1,640
Men employed		135
Time of run	days	61
Beets, average polarization	per cent	14.60
Beets, average sugar recovered	do	11.65
Sugar, average polarization	do	95.40
Sugar, average price	per pound	5.64 cents
Beets, average price	per ton	$5.04

No report has been received of the operations of the factory at Alvarado during the past season, and therefore I am not able to say whether or not the work was successfully conducted.

Mr. Fred Hinze cultivated an experimental plot of sugar beets at Douglass, Kans., during the past season. Considering the dryness of the climate and the high temperature reached during the summer, the results appear to be favorable. I am inclined to think, however, that the successful cultivation of the sugar beet for manufacturing purposes can not be looked for in such a climate as obtains at Douglass.

The analyses of the sugar beets at this station were made from time to time by my assistants at Douglass who had charge of the chemical work at the sorghum factory at that place. Following are the results of the work:

Date.	Brix.	Sucrose.	Coefficient of purity.
		Per cent.	
September 3	13.58	9.27	67.64
September 3	11.67	7.96	68.30
September 3	12.45	8.16	65.46
September 10	16.74	12.38	73.96
September 20	14.70	9.47	64.42
September 29	14.43	10.47	72.69
October 11	15.95	11.98	75.11
Highest	16.74	12.38	75.11
Lowest	11.67	7.96	64.42
Average	14.22	9.36	69.65

Great success also attended the growing of sugar beets in Nebraska at Grand Island. As will be seen by the following table, samples of these beets were analyzed by various chemists, and all found them excellent for sugar-making purposes.

Brix.	Sugar.	Coefficient of purity.	Brix.	Sugar.	Coefficient of purity.
	Per cent.			*Per cent.*	
*17.2	14.9	86.00	‡16.0	13.71	85.70
*18.9	16.1	85.00	‡17.1	14.2	83.00
*19.5	17.5	89.00	§16.3	13.10	80.40
*21.4	19.2	90.00	‖18.9	15.8	83.60
*19.7	16.7	84.00	‖18.2	15.20	83.50
*21.8	19.8	90.00	‖18.4	15.90	86.40
†18.8	16.4	87.10			

* Analyzed by Prof. William Huch, from Shoemingen, Germany.
† Beets harvested October 15, 1888, preserved in silo, analyzed January 2, 1889.
‡ Analyzed by Dr. Pauly, of Muhlberg, Germany.
§ Analyzed by Dr. Mueller, of Ottleben, Germany.
‖ Analyzed by Dr. Janke, Trendlebush, Germany.

Samples of these beets were also sent to the Department for analysis and entered as Nos. 6077 and 6078. The results of these analyses were as follows:

	6077.	6078.
	Per cent.	*Per cent.*
Juice extracted	56.16	54.70
Total solids in juice	18.40	18.80
Sucrose	15.38	15.75
Purity	83.59	83.77

As will be seen by the above analyses these beets were very rich in sugar, and if they could be grown in large quantities, which there is no reason to doubt, would indicate that in that locality the beet-sugar industry could be successfully established.

Another set of samples which had been harvested for three months was sent to the Department from Sturgis, Dak., and entered under No. 6162, a rose-colored beet, and No. 6163, a white beet. These samples were sent by W. C. Buderus, of Sturgis, Dak. On examination of these beets the following numbers were obtained:

	6162.	6163.
	Per cent.	*Per cent.*
Juice extracted	36.05	42.77
Total solids in juice	20.40	21.48
Sucrose	13.32	15.03
Purity	65.29	69.97

The low purity of the beets represented above was doubtless due to the fact that they had been harvested for a long time and no precautions taken to preserve them from deterioration. The analyses show that such beets could also be profitably used for sugar-making if worked up in a fresh state or preserved in proper kinds of silos.

The Department has had so many inquiries concerning the sugar-beet industry that the Commissioner of Agriculture has decided to issue another bulletin on this subject embracing the more important matters in bulletins already published, and which are entirely out

of print, and including the latest information accessible at the present time.

The coast valleys of California, large areas in Oregon and Washington Territory, parts of Nebraska, western and southern Michigan, northern Indiana, Ohio, and New York, and many portions of the New England States appear to be well adapted to the growth of a sugar beet rich in saccharine matter.

There is every reason to believe that the production of sugar from the sugar beet in this country will be vastly extended, and that beet sugar, in conjunction with sugar from sorghum and sugar cane, will be an important factor in the future sugar supply of the United States.

REPORT OF THE BOTANIST.

SIR: I have the honor to transmit herewith my report for the past year, together with some papers on economic plants, and a report on the "pastoral resources of Montana," prepared by Mr. F. W. Anderson, from personal observation. The investigation of the grasses of the arid districts has been continued, principally in Texas, a full report of which will be published in a bulletin. An experiment station for the trial, in cultivation, of such grasses and forage plants as give promise of usefulness in an arid climate, has been established at Garden City, in southwestern Kansas, and will be energetically prosecuted during the coming season.

Another grass station has been established in Mississippi, in connection with the State Agricultural Experiment Station near Starksville, to investigate and experiment with reference to grasses suitable for cultivation in the Southern States. If these stations are faithfully prosecuted through a sufficiently long period of time, I think the results will be highly beneficial to the grazing interests of the country.

Very respectfully,

GEO. VASEY,
Botanist.

Hon. NORMAN J. COLMAN,
Secretary.

GRASSES AND WEEDS.

1. *Reimaria oligostachya.*—This grass has not been found hitherto except in Florida and Cuba. It has been collected near Jacksonville by A. H. Curtiss, growing in ditches and on low grounds. It resembles some of the species of Paspalum, particularly *P. vaginatum*, and indeed can hardly be distinguished from the latter except by an examination of the flowers. The stems have a creeping habit at the base, sometimes running several feet, and rooting at the joints every inch or two. At the extremity the stems rise upward for a foot or two and develop the flowers. The leaves are 3 or 4 inches long, and very narrow, frequently becoming involute (folded or rolled together lengthwise) and sharp pointed. The sheaths of the leaves are loose, and generally as long as the joints of the stem.

The flowers are borne in spikes at and near the extremity of the culms, usually about three, sometimes two, and rarely four or five. These spikes are from 2 to 3 inches long, each with from ten to fifteen closely appressed spikelets. In structure the spikelets are like those of Paspalum except in having but two stamens instead of three, and in having the flower glume either entirely absent, or reduced in size to a fourth, a half, or three-fourths of the size of the other.

Generally the lower spikelets of each spike will have the lower glume absent, and the upper spikelets will have the lower glume in graded sizes to the uppermost, which may have two full empty glumes. The grass is nutritious and valuable for feed, but probably can not thrive except in the hot climate of the Gulf coast.

Plate I, Fig. 1, is a figure of this grass; *a*, a spikelct magnified showing the one empty glume, the flowering glumes, palet, two stamens, and two styles.

2. *Paspalum vaginatum.*—This grass is also a native of Florida and of the hotter parts of America, and is so similar to the preceding that the same general description will apply to it. It however seldom has more than two spikes in which the acute spikelets have the regular two empty glumes, and three stamens and two styles. It is not improbable that these plants may be found to be variations or forms of the same.

Plate 1, Fig. 2, shows *Paspalum vaginatum; b*, a spikelet magnified showing the empty glumes, flowering glume, palet, three stamens, and two styles; *c*, front view of the flower; *d*, flower opened to show the flowering glume and palet.

3. *Paspalum distichum.*—This grass is in habit very similar to the preceding, but usually grows on drier soil, with taller and more erect culms. The leaves are generally wider, the spikes are rarely more than two, the spikelets are smaller and more numerous with two empty glumes, and the flowers have three stamens. It has a wider range than *P. vaginatum*, being found in the Southern States from Virginia and Tennessee to Florida and Texas, thence to California, and as far north as Oregon. This species, as well as several others of the genus, has received some attention in the South as being useful pasture grasses. Their creeping habit gives them stability and capability to endure drought, and they form a close, tenacious sod, well adapted to close pasturage. At the same time, under favorable circumstances, this species produces a large yield. Mr. W. A. Saunders, of California, writes recently as follows:

> Are you aware of the value of *Paspalum distichum* for seeding pond-holes that dry up, or nearly so, in autumn? Such ponds are usually spots of bare, stinking mud, but when well set to this grass will yield all the way up to 80 tons (in the green state) of autumn feed for stock, especially valuable for cows first; then follow with sheep until every vestige is devoured. Surely it has an immense food value in such places.

Plate 2 shows *Paspalum distichum; a*, a spikelet enlarged; *b*, the same expanded, showing the two empty glumes and the flower.

4. *Setaria viridis* (Green Foxtail).—In almost all cultivated and waste grounds, particularly in wheat fields after cutting, there is found an abundant after crop of what is called pigeon grass or foxtail. There are two species of this foxtail, which, although found in the same field, may be easily distinguished. One is *Setaria glauca*, with an erect culm and cylindrical spike, and the bristles of which are usually of a yellowish color. The other is the *Setaria viridis*, which has a weaker stem, the spike rather looser, tapering at the apex, and with the bristles longer, and green in color. In this species also the spikelets are rather smaller, the lower glume shorter, and the grain less distinctly wrinkled. The seeds of both kinds are eagerly sought for by birds and poultry in grain fields after harvesting. The grass is probably introduced from Europe.

Plate 3 gives a view of the grass; *a*, a single spikelet enlarged, showing the parts and the bristle below.

5. *Oplismenus setarius.*—This grass is found in Florida and in other States near the Gulf of Florida, reaching to Texas, and thence into Mexico and other tropical countries. It grows in woods and shady places. The stems are at first prostrate, often branching and rooting at the joints. They send up a weak flowering culm, with a loose raceme 4 to 6 inches long, composed of five or six short, sessile, one-sided spikes, about half an inch long, each containing from six to twelve spikelets in two rows on the rhachis. The spikelets each contain one perfect flower, and one which is male or only rudimentary, and have three empty awned glumes, the lowest of which has the awn two or three times as long as the spikelet. The flowering glume is awnless, and like a Panicum.

Plate 4 shows this grass; *a*, a single spikelet enlarged, showing the awned lower glumes, and the two flowers, one male, the other perfect. Although this grass furnishes a considerable amount of good wild forage, it is not probably adapted to general cultivation.

6. *Beckmannia erucæformis* (Slough grass).—This genus is closely related to Panicum and has considerable resemblance to some forms of *Panicum crus-galli.* It grows abundantly in the Rocky Mountain region from California and Oregon eastward as far as Iowa and Minnesota. It is found in marshy ground and in sloughs, particularly in the neighborhood of streams.

It usually grows in tufts, and is of a coarse growth, the stout roughish culms rising to about 3 feet in height; the thickish leaves are about half an inch wide and 6 to 8 inches long. These as well as the loose, long sheaths are strongly marked with numerous parallel veins. The panicle is generally long and narrow, from 6 to 10 inches long, and half an inch to an inch wide, composed mostly of many very short, closely set branches, which are more or less interrupted below, where the branches are generally longer, sometimes 2 inches long and erect.

The spikelets are crowded very closely together on the one-sided spikes, and each one consists of a pair of thickish, compressed, inflated, boat-shaped, empty glumes, and between these, one lanceolate-acute flowering glume, of thinner texture, with its still thinner palet, and the stamens and styles. These are represented in Plate 5, *a* showing an enlarged spikelet, *b* the same expanded to show the separate parts. In some localities this grass is abundant and forms a valuable resource for stock. The bottom leaves and sterile shoots are tender and much relished. Mr. F. W. Anderson says:

> It makes good hay. When the plants are thick together the aftermath of slender, juicy leaves quickly grows, remaining green till quite late in the year. It is to be recommended for cultivation in low, wet meadows generally.

Others, however, regard the grass as coarse and without value.

7. *Anthenantia rufa.*—Culms erect, 2 to 3 feet high, from strong creeping rhizomas; leaves rather rigid, linear, 10 to 15 inches long, three lines wide, abruptly pointed, and with the sheaths of a purplish color; panicle 4 to 8 inches long, narrow and loose, the branches in clusters of 3 to 5 or more below, flowering nearly to the base; spikelets on short, slender pedicels, loosely racemose on the branches, each containing one perfect flower, and one neutral or imperfect one, the two outer glumes five-nerved, hairy, as long as or longer than the flowers; the perfect flower with a rigid glume and palet, the sterile flower with a thin membranaceous palet. This species occurs in low and swampy pine woods in the Southern States from North Carolina to Mississippi. No efforts have been made in its cultivation.

Plate 6 represents this grass; *a*, a spikelet enlarged; *b*, the same expanded showing the separate parts.

8. *Amphicarpum Purshii.*—An annual or biennial, erect, rigid grass, growing 2 to 2½ feet high, in the sandy pine barrens of New Jersey, Delaware, and the Southern States. The leaves are mostly at the lower part of the culm, lanceolate, acute, rough (especially on the long sheaths), 4 to 6 inches long and three to four lines wide. The panicle is rather close, 4 to 6 inches long, the slender branches erect, sometimes single and sometimes in twos or threes, 1½ to 3 inches long, rather loosely flowered. The spikelets are sessile, or very short-stalked, and consist of a pair of lanceolate, acute, five-nerved empty glumes, and a single flower with rather rigid glume and palet, and with three stamens and two styles. These flowers, although apparently perfect, do not produce seed, but there is another kind of spikelet at the base of the culm which bears the seed. These are borne at the extremity of long, slender peduncles or secondary culms, one or two on each peduncle. They are twice as large as the spikelets of the panicle, and have thickened, many-nerved outer glumes, with the flowering glume and palet hardened. There are but two species of this genus known; the second one is found in pine-barren swamps in Florida. They furnish a certain amount of feed in the sandy pine lands of the Atlantic coast.

Plate 7 shows the plant with the two kinds of spikelets; *a*, perfect flower enlaged; *b*, the same expanded; *c*, the seed; *d*, a fertile flower enlarged and expanded showing the parts.

9. *Leersia Virginica* (Rice-grass).—This is a common grass in damp, open woods, and along the margins of streams.

It is weak-stemmed and much branched, growing about 3 feet in length, with an abundance of bright-green leaves, 4 to 6 inches long, 3 to 4 lines wide, and having rough margins. The main culm and the principal branches are terminated with a slender panicle of 4 to 6 branches, which are at first appressed to the main axis, but finally become spreading These branches are single and slender, from 1 to 2½ inches long, the lower part naked, the upper part closely flowered. The spikelets are very small and consist of two glumes, inclosing the stamens and styles. The outer glume is broad-oblong, thickish, and much compressed or flattened, and is rough on the back and margins with stiff, short hairs. The second glume is much narrower, and also rough on the nerves. There is no palet, but the stamens and styles are inclosed by the upper glume.

This grass furnishes a part of the native feed in open, wet woods, and is sometimes sufficiently abundant to be cut for hay.

Plate 8 is a figure of the grass; *a*, an enlarged spikelet showing the separate parts.

10. *Poa Andina.*—This is one of the many "bunch grasses" of the West, so named from its habit of growing in bunches. It is an inhabitant of all the interior mountainous country and of the high plains.

It grows from 1 to 1½ feet high, with an abundance of root-leaves, which are about half as long as the culms, very narrow and stiff, folded or rolled together lengthwise, and very sharp-pointed. The leaves of the culm are very short, erect and stiff; the lower one about 2 inches; the second, 1 inch long, and the upper one shorter; all of them have loose, striate sheaths. The panicle is usually lanceolate or oblong, 2 to 3 inches long, and about half an inch wide, close and densely flowered; the branches short (one-half to three-fourths of an inch), and mostly sessile and alternate, the lower one sometimes at a

short distance below the others. The spikelets are about three lines long, with five to seven crowded flowers. The empty glumes are thin, ovate-oblong, two lines long, the lower, one-nerved; the upper, broader and one-nerved or faintly three-nerved below; the flowering glumes are about two lines long, more or less rounded on the back, very thin and blunt at the apex, either nearly smooth or softly puberulent on the back, and ciliate on the margins.

Attempts should be made to introduce this species into cultivation in the arid districts.

Plate 9, a figure of the grass; *a*, an enlarged spikelet; *b*, a floret expanded and showing the separate parts.

11. *Agropyrum glaucum* (Colorado Blue-stem).—This species prevails on the western plains and in the mountains, and is well known to stockmen. It is generally known by the name of blue-stem, or blue-grass, and is sometimes called gumbo-grass.

It is closely related to the quack-grass or couch-grass of the Eastern States. It has a stiff, erect culm and leaves, which are usually of a bluish-green color. On hard, dry soil, its growth is low and sparse, but on low, moist ground it often grows 2 to 3 feet high, and is considered valuable for hay. On the borders of ditches and on irrigated ground it yields a heavy cutting. The flowering spike has somewhat the appearance of a starved, beardless head of wheat. It has great persistence in the ground on account of its strong, running rootstock. Whether it will, in cultivated ground, become as difficult to eradicate as its eastern namesake can not now be predicted, but where a persistent, nutritious grass is the great want of a country, as on the arid plains, it is worth taking some risks.

Fig. 11 represents the species; *a*, an enlarged spikelet consisting of the two empty glumes, and nine florets, two of which are expanded and show the separate parts.

12. *Plantago Patagonica* (Western Plantain).—The specific name which this plant bears would indicate that it was a native of Patagonia. It was probably first described from Patagonian specimens, but is extensively spread throughout South America, and into various parts of North America, particularly on the Pacific coast, and from Mexico into Texas, the Great Plains, and through the Mississippi Valley into British America. Within a few years past it has spread into many places in the Eastern and Southern States. It belongs to the plantain family (Plantaginaceæ), and presents a number of marked varieties.

It is a small, annual plant, seldom more than 10 or 12 inches high, and, like most of the family, has its leaves clustered near the ground and sends up one or more slender flowering stalks which are naked below, and above, present a close spike of flowers succeeded by seed. The leaves are very narrow, 3 to 5 inches long, with a few prominent ribs running nearly parallel from base to apex. The variety which is figured is generally clothed with soft, silky hairs. The flowers are small and present the characters common to the genus, which we need not here particularize. They are succeeded by the very numerous small capsules or seed vessels, which are oblong, with thin walls, and each containing two large seeds. These capsules have a remarkable way of opening to discharge their seeds. Near the middle of each capsule and passing round it horizontally is a line or mark, where, at maturity, the upper part separates like a lid, and exposes the contained seeds.

Mr. F. W. Anderson states that in Montana this plant is causing

trouble in hay-lands. It is self-seeding and very prolific. The seeds ripen and spring up the same season and mature the next year. Where nothing hinders the development of the plant, by its very numbers it drives out the grama and blue-joint grasses in large patches. In the spring, just before the flowers open, a patch of these plants looks like hail on the ground at a little distance, owing to the thousands of white, silky-villous spikes which rise in all directions. Stock do not like to eat the plant, and farmers are beginning to detest it.

Plate 11 represents this plant; *a*, an old spike gone to seed; the bracts are very conspicuous; *b*, a younger spike in flower; *c*, a very young spike; Fig. 1 shows a back view of the flower with the calyx removed; 1, *a*, the mark of circumscissile dehiscence; Fig. 2, a front view of the flower, the calyx present and a short bract at its base; Figs. 3 and 4, portions of empty capsules, front and oblique views, showing central placenta; Figs. 5 and 6, dorsal and ventral views of a seed.

Figs. 1 to 6 greatly enlarged.

13. *Lygodesmia juncea*.—This is a homely, scragged, perennial weed, prevailing throughout the Rocky Mountain region. It is a naked-looking composite plant, closely related to the chicory plant of Europe. It grows about a foot high, with a rigid stem and branches which are marked with fine ridges and furrows. The leaves are small and inconspicuous, the larger ones being linear-subulate and about an inch long, one at the base of each of the branches, the upper ones becoming gradually reduced to small bracts or scales. Each branch is terminated by a single head about half an inch long, containing five flowers surrounded by an involucre of slender scales, and a few much-reduced ones at the base. The flowers are all of the strap-shaped form, having a broad fringed summit, and of a rose color. At the base of the flower is the *akenium* or seed, surmounted with a copious tuft of long, white hairs, constituting what is called the *pappus*. The *akenes* are linear and five-ridged or ribbed.

Mr. Anderson states that the plant is native and common in Montana, and has a deep, perennial root which it is hard to destroy. It is especially pernicious in vegetable gardens, where it easily chokes out young plants and causes much trouble. It will thrive in hot, dry weather, when most other plants are weakened by the heat and drought. Hoeing up the plants while the flowers are in bud is recommended. The plant blooms and scatters seed from the end of June till October, so that an enormous number of seeds are matured each season. In cultivated ground the plant becomes much distorted.

Plate 12 represents the plant; Fig. *a* is a branching stem torn off near the base; Fig. *b*, a single floret; *c*, a seed with its pappus; *d*, an empty involucre showing five punctures on the receptacle where the florets were attached; *e*, a portion of a thicker stem, showing one of the larger leaves.

14. *Solanum triflorum* (Wild Potato).—A low, herbaceous, much-branched and spreading plant of the same family as the common potato, growing on the plains from New Mexico northward into British America. The stem and branches are weak and decumbent, seldom over a foot long, but very numerous from one root. The leaves are alternate, 1 to 2 inches long, oblong in outline, deeply cut into lobes, from three to five on each side, and tapering below into a narrow margin. From the axils of the leaves there proceed slender *peduncles* or flower-stems, about an inch long, each bearing about three small, white or pale-blue flowers, which resemble those of the

common potato but smaller. Each of these flowers is succeeded by a small, greenish berry, containing numerous small seeds.

Mr. Anderson says of this plant, that five years ago it was comparatively rare in northern Montana. It could then be found here and there on the prairies or near water-courses, but during the past three years it has notably increased, owing to the increased cultivation of the soil.

The plant grows better in cultivated ground, and it is a fact worth recording that it grows best of all in situations particularly suited to the development of the common potato (*Solanum tuberosum*). In its final condition the plant spreads on the ground in mats 3 feet or more across, the branches usually rooting all along the parts touching the earth, and bearing many pale blue to purplish flowers. I had noted several years ago that potato-bugs live upon the leaves. In 1887 and 1888 an enormous crop of potato-beetle larvæ were produced, chiefly upon this weed. It is a regular swarming place for Colorado beetles, which lay eggs by the thousands on the leaves everywhere.

Plate 13 is a figure of this plant; *a*, *b*, a flower and bud enlarged; *c*, a cluster of mature berries, with a tuft of leaves; *d*, a berry cut transversely; *e*, a berry cut vertically.

The grasses of Plates 1 to 11 are onê-half the natural size.

THE PASTORAL RESOURCES OF MONTANA.

By F. W. ANDERSON, *Special Agent.*

Not many years ago this Territory was regarded as a part of the vast waste called the Great American Desert. Even her wealth of mineral resources was not realized, and the country was considered fit only for the hunter, the trader, and the Indian agent. But at last, when the rich mineral discoveries of Alder Gulch and Virginia City created such a stir, miners, adventurers, and fortune-seekers flocked to the Territory from all directions. It was then that people began to see in the mineral productiveness of the soil a promise of future greatness for Montana. Mine after mine was discovered, keeping alive for years the feverish excitement incident to gold hunting on the "bars," for nearly all mining in those days was *placer*. Long years before the shriek of the locomotive echoed with shriller notes in Montana's mountains the hoarse cry of the "bull-whacker" and the sharp crack of his quirt affrighted the timid game feeding peacefully on the mountain slopes. In those days the value of a good mule or ox train was estimated at about $6,000 in gold, and many a fortune has been made, and often lost again, carrying provisions and implements of toil to the hardy pioneers of the Territory. Soon it was discovered that mules and oxen grew fat on the native grasses, thus suggesting possibilities in another direction, viz, that of stock-raising. At first it was feared the extreme cold of winter could not be withstood by cattle or horses on the open ranges. It was considered out of the question to feed hay, for that was worth $60 a ton, sometimes more. However, wintering cattle on the open ranges was tried, but with discouraging results. A few of the originally imported stock still survived, and, in a measure, had become acclimated. These passed through a milder winter than usual, and spring found them in fair condition. They bore fine, healthy calves, and thus fresh hope was infused into the minds of experimenters.

From that time on the stock business has steadily increased until

now it has reached magnificent proportions; and as one travels over the Territory north, south, east, or west, he is pointed out with pride, by the inhabitants, the costly residences and large herds of cattle owned by the "cattle kings," as the successful men have been dubbed.

Where Captains Lewis and Clarke, the explorers, over eighty years ago saw thousands of buffaloes, elks, and deer feeding on the open plains bordering the Missouri River, near the falls now roam thousands of horses and cattle which obtain sustenance the year round by eating the native grasses. Upon the same plains a hundred years ago the Indians' horses also grazed.

MINING AND STOCK-RAISING.

The two leading industries are mining and stock-raising. Quartz mining is now the chief branch of the former; but in early times placer mining, because of the remoteness of the country and difficulty of access, was the only branch sought and pursued. The manner of raising stock is very simple. Horses and cattle are permitted to roam over their owners' ranges at will, and are "rounded up" only for the purposes of branding, castrating, counting, and selling, all of which work is usually performed at stated times of the year. But sheep, although kept in large flocks or "bands," are cared for by a shepherd or "herder," partly because they scatter far and wide in small groups if left to themselves, and partly because they need protection from wolves and coyotes. The average-sized band of sheep will probably contain 2,500 head, but many flocks number over 5,000 head; but these are too many for one man to properly care for, and the weak, the old, and the lame animals have a hard time of it.

While horses, cattle, and sheep all bring forth their young on the open plains, sheep are the only stock receiving any attention at this period. Extra men are employed during the "lambing season," and the flock is generally divided up into three—those to lamb, those lambing (or within a day or two of it), and those that have lambed; this is done for obvious reasons.

Cattle are raised for beef, no practical attention yet being paid to dairying; horses are raised for speed and endurance, very few draft animals being bred; while sheep are hardly ever raised for any purpose but wool-growing. But the time is close at hand when every industry connected with these animals will receive its merited attention.

GENERAL FEATURES OF MONTANA.

The southern and western parts.—Looking at a map of the Territory one sees that the southern and western parts are much broken by small, isolated groups of mountains and hills. If one traveling over these parts will take time to climb a few of these mountains he will see at once, that this is the exact nature of the country. Far below him he will see valleys and plains of greater or less extent surrounding each little range. Looking towards any point of the compass he will see the same plains wandering between and around other isolated mountain groups in the distance, strongly reminding him of a great quiet lake, dotted with huge, rocky, often pine-clad islands. These groups are all called ranges by the local inhabitants, but many of them seem too small to deserve such a name.

Looking at the map again one will observe the course of the main divide of the Rocky Mountains. Well defined and broad, it retains

its individuality from near the northeast corner of Missoula County, through the eastern and central length of Deer Lodge County, and half through Silver Bow County on its eastern border. Here it becomes broken and fragmentary. The Bitter Root Mountains extend along the southwestern border and continue all along the western line as far north as the forty-eighth parallel in Missoula County. Much of the country between the Bitter Root Mountains and the main range is very rugged. So far as I have seen the prevailing rocks in these regions are gray granite, porphyry, slate, and limestone, but occasional large areas show outcroppings of a reddish-colored lava. Especially was this last feature observed in the vicinity of the McCartney Range in the northeastern corner of Madison County.

The majority of the little mountain clusters contain in their bowels gold, silver, copper, and lead. Ironstone of several varieties is also abundant, so that iron and lime for fluxing the other metals are mostly near at hand, while the charcoal is made in the pine woods on the neighboring heights. In a few of the ranges free gold is found; very few of the diggings are rich, however, seldom paying more than ordinary days' wages ($3.50 to $6), while some few yield almost fabulous amounts per annum.

The plains already mentioned are mostly high, often stony, and, so far as I have seen or heard, always dry. The numerous valleys, through nearly all of which flows a stream of sparkling water, are for the most part narrow, but very productive. The chief crops appear to be oats, wheat, timothy, and native "bluejoint," potatoes, cabbages, turnips, and onions; corn is not grown as a regular crop. Fruit trees of any kind are rarely seen, and even then have only been planted by persons of unusually enterprising and progressive spirit. Even the small fruits, like gooseberries, currants, raspberries, and strawberries, are not cultivated, although ample evidence is given to show that they and other small fruits would do well; for many persons have volunteered the information that they go into the mountains once a year to pick a year's supply of these fruits for use in their families.

In these valleys and up many of the mountain gulches grow several species of poplar and willow. The balsam poplar is the commonest of the genus. *Salix flavescens*, var. *scouleriana*, *S. rostrata*, and *S. longifolia* are the common willows. Occurring with these are also the black or "mountain" birch (*Betula occidentalis*), which sometimes attains a size rarely seen in the northern part of the Territory, and a species of alder (*Alnus viridis*), often growing to a height of 30 feet. Occasionally such evergreens as *Juniperus communis* and *J. Virginiana* may be found also. On the mountain slopes several species of pine and fir occur. But the mountain tops are bare, or at most support a scattered growth of dwarfed pine (*Pinus albicaulis*, Eng.).

The high plains or benches for the most part produce a very thin growth of grass. In many localities are immense tracts, miles in extent, covered by sage-brush (*Artemisia tridentata*) growing to an average height of 4 feet; specimens are occasionally seen 6 feet high. The woody stems of this strange under-shrub are used as fuel in some parts. Another sage-brush (*A. cana*) is also common. It never is so tall or robust as *A. tridentata*. Greasewood (*Sarcobatus vermiculatus*), with its cruel spines, is abundant in many localities. It grows into a good-sized bush 4 or 5 feet high and very branching. The numerous short, rigid branchlets are usually tipped with a sharp point, giving them a spiny appearance. One may be severely

pricked in forcing his way through a patch of this shrub. I am informed, however, that this plant, despite its formidable appearance, is eagerly sought by range cattle, which live upon it when the snows are deep. I have seen cattle munch the branches, spines and all, as composedly as a donkey eats a thistle. The local inhabitants in the spring, when the young shoots are green and tender, boil them as "greens," and sometimes make pickles of them, too. I have not tasted cooked twigs, but have eaten the raw, succulent, linear leaves. The flavor is almost identical with that of the well-known samphire of our coasts. One more under-shrub contributes largely to the characteristic appearance of the southern and southwestern parts of the Territory, viz, *Bigelovia graveolens*, var. *albicaulis*. Like the sage-brush and greasewood it chiefly inhabits the high benches and dry bottoms. This variety seems to occur throughout the Territory; but nowhere, so far as I have observed, is it so common as in the counties of Silver Bow, Beaver Head, and Madison. Here we find it averaging 3 feet high, making the plains yellow for miles in late summer with its profusion of flowers, and in autumn imparting a peculiar grayish-green tint to the landscape. No animal seems to eat this plant, and, aside from the facts that it helps to cover the nakedness of the earth and draws a little moisture, it is to be regarded as a troublesome weed.

Agriculture, then, in the regions described is confined almost wholly to the narrow valleys and bottoms, along streams; it is not a chief industry, and never can be, owing to the very nature of the country. Mining takes the lead, stock-raising comes next. Here is a grand country for the latter purpose. Despite its dry plains and abominably numerous steep mountains and hills, it is abundantly watered. Scarcely one of its thousands of valleys is without a brook or a river of the purest water, easy of access. In many localities the grass forms a close turf. In this respect the southern parts of Madison and Beaver Head Counties can not be excelled. In making a random guess I would say that fully three-fourths of this entire region would always be open to the interests of stock-growers of all kinds. It is a splendid country for the purpose.

Northern and eastern Montana.—We now come to a wholly different country: the general appearance, the vegetation, and even the climate, all different. Here we have the three grand resources, mining, stock-raising and farming, on a more nearly equal basis, but instead of mining, stock-raising takes the lead. And here wool-growing is an important item.

Looking at a map of these parts we see a country abundantly watered and possessing only a few (comparatively) mountain ranges. The many creeks or brooks and larger streams all find their way to one of three great rivers. The central river, the mighty Missouri, then receives the two others—the Milk River from the north and the Yellowstone River from the south. Ascending to the summit of any convenient mountain in northern Montana, and looking as far as the eye can reach with the aid of a field glass or telescope, one sees a grand series of beautiful rolling plains, thickly covered with grass. Here and there the winding valleys mark the courses of the streams. In the distance are mountains, purple, and blue, and gray. To the south and west one sees, though so far, the main range of the Rockies, its snow-clad peaks in bold relief. That range can be distinguished at a glance from all others.

Here we have a country pre-eminently fitted for pastoral and agri-

cultural pursuits. The extent of range for stock would be simply inexhaustible were not the soil so rich that agriculture is rapidly taking possession. In fact it is my opinion that in a very few years agriculture will have such a pre-eminence that herd laws will be enacted, at least for the protection of farmers in this region. Agriculture is making gigantic strides. It has been satisfactorily proven that the justly celebrated wheat lands of Minnesota and Dakota can not surpass the bench lands of northern and eastern Montana. Hundreds of progressive farmers and others are planting timber and fruit trees, everywhere meeting with success. So it is easy to foresee that in a few years the country will be so settled by farmers and growers of fine-blooded stock, who will keep their animals in pastures or other inclosures, that range stock will be crowded to the foot-hills and mountains, or else their owners will have to take them to those regions where there will never be a struggle between the tiller of the soil and the flock-master for possession of the field.

If one will go over any portion of the region now under consideration, after having gone over those parts described in the previous section, he will at once notice the difference in the vegetation. Nowhere here, except in the "bad lands" along certain portions of the Missouri River and in a few other parts, will be seen the sage-brush, Bigelovia, and greasewood, in any abundance. In going over the ground during summer the difference will be still more marked by the presence of a great variety of leguminous plants, many of them very beautiful in flower and foliage, which are dotted over these northern plains in all directions. In my own herbarium are twenty-three species and several varieties, representing the genus *Astragalus* alone, all collected in this region.

Along the small streams and rivers the common trees are *Populus monilifera*, *P. angustifolia*, *P. tremuloides*, and more sparingly *P. angulata*. Only one willow ever seems to become truly tree-like in size, viz, *Salix amygdaloides*. This species usually becomes of sufficient size for good, solid fence-posts, and at times even larger. It is considerably used for that purpose. Professor Coulter in his Manual of Rocky Mountain Botany, page 335, quotes that a form of *Salix cordata* sometimes affords durable timber, adding that "it is altogether incredible that any form of *S. cordata* ever attains tree-like size." So far as personal observations enable me to judge I think Professor Coulter is quite right. The very largest specimen of *S. cordata* I ever saw was not more than 5 inches in diameter at the bottom. It was the var. *vestita*, the common diamond willow, the same form that Professor Coulter comments upon. But *Salix amygdaloides* frequently becomes 18 inches in diameter. Where abundant it is much cut for cord-wood, making excellent fuel. Towards the mountains the poplars all disappear save *P. tremuloides*. The willows also are different, *S. rostrata* and a form of *S. glauca* being most common.

CLIMATE.

The climate of this Territory is a remarkable one. The winter weather of any new country is always the subject of special inquiry, particularly when stock-raising is in question. The following notes upon this and the other seasons may be of interest:

Winter.—Winter generally sets in in good earnest in the early part of January, seldom much snow or cold before then, and lasts until the middle of March or beginning of April. It is not a period of steady winter weather, however; a "cold snap" seldom lasts over

two or three days. According to statistics the average snow-fall in the course of a winter is about 18 inches. This does not fall all at once; neither does it fall from time to time, and accumulate for the genial warmth of the spring to dissipate. Here, in mid-winter, the mild breezes blowing inshore from the Japan Current sweep down over the mountains, often melting a foot of snow in a single day or night, and seldom letting one snow-fall lie upon the ground over two or three weeks. In this way the ground is frequently left bare for several weeks before the advent of another storm. At such times men go about in their shirt-sleeves, insects skip and fly about the prairies, and stock upon the ranges gain flesh. Some winters, however, the snow becomes crusted hard for weeks at a time; then range cattle suffer terribly, and many of them die because they can not get at the grass. Horses and sheep paw holes in the snow, "rustling for feed," hence seldom suffer. Cattle never paw; if they can not push the snow off the grass with their noses they starve or eat willows, which is nearly as ruinous. But the loss of cattle from this cause is not necessary, as it would take but little hay to keep them alive till a "chinook" came to break the icy bonds.

Spring.—Spring follows close upon winter; there is no gradual transition. Before the last chinook has swept away the snow-drifts, wild flowers of brilliant colors appear. Spring frosts rarely occur, except very close to and in the mountains. Farmers put in their seeds as soon as the ground is thawed enough for plowing, and seldom give them further attention till harvest time. In northern Montana an ample supply of rain falls during May and June. Spring here is nearly as warm as summer; for this reason, combined with the abundance of rain, vegetation grows with surprising rapidity. The "blue-joints" and other tall grasses are usually 3 feet high by the middle of June.

Summer.—This season may be said to develop from spring about the middle of June. Its hottest period is in August. Sometimes, but not often, the temperature is over 110° F. in the shade. The probable average is about 80° F. It is well known that sea-breezes are warmer in winter than the land atmosphere, and that they are cooler in summer; and so it happens that the same breezes which melt the snow and moderate the severity of winter here, gently blow, cool and refreshing, over the mountains and plains in summer time. Consequently, the heat of summer has not that oppressiveness so characteristic of it in "the States." It is seldom that one can not fully enjoy the comfort of a woolen blanket during a summer night.

Autumn.—Montana's autumn weather is perfect. The nights are cool, often frosty; the days are bright and mild. Whenever we have a good fall, stock are in prime condition for market, or to face the cold weather coming. This fine weather generally lasts till well on into November. (This year it is yet fine, and I sit writing this, the 22d of December, with my door wide open.) Then a small snow-storm occurs occasionally to remind one that winter has almost come again.

We have now glanced over the general features of the Territory, and in so doing have seen that the greater part of it, at least four-fifths, can be utilized for stock-raising. We have also seen that nearly half of it will eventually be devoted to agricultural interests. The south and most of the western part will always be a pastoral country, while the north and east will soon be almost entirely devoted to farming, horticulture, and the raising of fine, blooded stock, for which purpose very extensive areas are not needed by individuals. We have seen that, on the whole, the climate is a good one. This

good climate is probably mainly the result of two features, the close proximity and protection afforded by the main range of the Rocky Mountains, with its numerous spurs, and also of the cooling influence of the chinook wind blowing from the Japan Current in summer, and its warming influence in winter.

NATIVE GRASSES.

In agricultural circles there has been much talk about the "bunch grasses," "blue-joint grasses," and "buffalo grasses" of the Northwest. I shall not here pretend to present as large a list as Professor Scribner's "Agricultural Grasses of Central Montana," not having the necessary material to draw from; but the following list gives our most important species, as I have found them, in different parts of the Territory:

Beckmannia erucæformis, Host (Beckmann's Grass, "Slough-Grass").—Found throughout in low grounds, marshy places, and sloughs; to some extent also along the banks of mountain streams. In some localities it forms a valuable food for stock. Average height about 3 feet. The stout culms give off several bright-green leaves, 4 to 8 or 9 inches long. Several culms usually grow from one tuft. At the bottom of the plant are tender leaves and sterile shoots much relished by stock. It makes good hay. Where the plants are thick together, the aftermath of tender, juicy leaves quickly grows, remaining green till quite late in the year. To be recommended for cultivation in low, wet meadows generally.

Panicum capillare, L. (Panic-Grass, "Fool-hay").—Throughout; forming large "meadows" in some localities. Mostly found in waste or gravelly soil. Sometimes called "Fool-hay," because it takes so much to make a ton.

Panicum crus-galli, L. (Barnyard-Grass).—Professor Coulter in his Manual, page 404, says: "Very widely introduced, possibly indigenous somewhere on the continent." Undoubtedly indigenous here; occurring along streams and in gravelly places throughout. In the mountains usually dwarfed. Sparingly introduced into cultivated ground. Stock eat this grass readily. Leafy, many-stemmed, hardy, "self-seeding" unfailingly, it has much to recommend it.

Setaria viridis, Beauv. (Green Foxtail, Bottle-Grass, "Wild Millet").—Introduced into cultivated soil. Not common. Many farmers look upon it with great favor.

Spartina cynosuroides, Willd. (Cord-Grass, Marsh-Grass).—Throughout, in marshy ground along streams, and in depressions of valleys. So abundant in some localities that eventually it may cause serious trouble. In some of the meadows near Helena it constitutes nearly half the grass. It spreads by strong, scaly root-stocks, each of which is tipped by a stiff, sharp point, formed by the overlapping, terminal scales. Culms average 4 feet high, stiff and reed-like. Stock will not eat this grass, and it is useless for hay.

Phalaris arundinacea, L. (Reed Canary-Grass).—This valuable grass is common throughout. Abundant along many of the mountain streams and in moist valleys everywhere, especially in the southern part. Prefers moist situations, attaining a height upwards of 5 feet. Makes excellent hay. Cattle are very fond of the leaves and panicles. The latter, when full of seeds, they nip off and eat with evident relish. This species would pay well in cultivation, owing to the abundance of hay it would yield. (*Phalaris Canariensis*, L., is sparingly introduced.)

Hierochloa borealis, R. and S. (Vanilla-Grass, Seneca-Grass).—Is said to be common in some parts. I never saw it myself except along the banks of Belt River, in Meagher County.

Alopecurus pratensis, var. *alpestris* (Mountain Timothy).—This species has an unexcelled reputation as a grass for the pasture and hay-mow. Growing extensively in the mountains it often covers large open tracts known as "mountain meadows" and "parks." It is regularly cut for hay, and the delicious odor exhaled during the curing process is indeed "the scent of new-mown hay." There is no necessity for introducing foreign grasses into any region possessing a native species like this.

Aristida purpurea, Nutt. (Triple-awned Grass, Bunch-Grass).—Common, especially south and southwest. In the northern part the variety *longiseta*, Vasey, appears to be the prevailing form. Chiefly on gravelly, stony ground along bluffs and rocky hills in the northern part, but southward it is very abundant in some localities on the dry plains so characteristic of that region. Its habit of growing in stiff clumps, narrowed below, diverging above, has gained for it the usual name, "bunch grass." Cattle and horses eat the green clumps freely, but sheep prefer other grasses. A valuable adjunct to winter ranges; sheep, even, are often glad enough to eat it in winter.

Stipa comata, Trin. and Rupr. (Feather-Grass, "Bunch-Grass," "Needle-Grass," "Needle-and-Thread").—This common grass is known here by all the popular names except the first. Found throughout. It has the "bunch-grass" habit, the culms seldom exceeding 3 feet, usually but half that height. Stock are fond of the numerous, narrow, involute leaves crowning the base of the bunch. Commonest in poor soil and where "bed-rock" is near the surface.

Stipa viridula, Trin. (Feather-Grass, Bunch-Grass, "Wild Oats").—With the last, but apparently more abundant in richer, damper soil, attains a height of 4 feet, and in moist situations a still greater. Where thick enough it is cut for hay, of which it makes a fair quality. Stock like the seeds, which are numerous and taste like oats. I have frequently seen both sheep and cattle fight with their own kind over a well-seeded panicle of this grass.

Stipa spartea, Trin. (Feather-Grass).—Known here by the less delicate but certainly more appropriate name of "Devil's Darning-needle." This wretched grass is not common anywhere that I have been in Montana except in the foot-hills and valleys bordering the north aspect of the Great Belt Mountains near to the West Fork of Hound Creek and "the old Fort Logan road." It is to be hoped that it will not spread for years to come. In traveling afoot where this grass grows when it is in seed one is kept busy picking the surprisingly sharp-pointed seeds with their strongly-twisted awns out of trousers and sleeves. If allowed to remain these seeds rapidly insinuate themselves into the flesh. I have seen horses and cattle with the awns sticking out of their skin while the seed was completely buried beneath. The poor creatures suffer severely at times from the irritation thus set up. This grass has been reported from one or two other localities, but is said not to be common.

Oryzopsis cuspidata, Benth. (Mountain Rice, "Bunch-Grass").—This valuable grass is common throughout. Usually in clumps varying from 1 to 3 feet high. In the southwestern part it does not average over 8 inches high and one or two culms to a plant. The leaves are long and very narrow, growing from the middle and lower parts of the stem, usually few or none arising from the base. Panicle often

included below, but very open and branching above. From the tips of the slender branchlets grow the hard, nut-like flowers and seeds. The seeds are very nutritious, as good as oats, and are greatly relished by stock, especially cattle. This grass grows up early in the season and may be still found in a comparatively green state late in the fall, long after the seeds have ripened and fallen off. It would doubtless do well in cultivation, and seems to flourish best in sandy soil, where its long, fibrous roots always draw up the moisture. The fact of its being so nutritious and at the same time capable of thriving in what is usually considered the poorest of soil makes it well worthy the attention of all western Experiment Station authorities, as well as of northwestern farmers.

Oryzopsis micrantha, Thurber (Slender Mountain Rice).—Common but not abundant in many localities. Being less conspicuous than the last it has been generally overlooked. It is supposed to grow in Montana mainly at the highest elevations. Often nearly as tall as the last, but always very slender; the few and narrow branches of the panicle arranged in pairs. Many culms, fifteen or more usually arise from one tuft. Very leafy below; leaves narrow and setaceous-tipped, 4 inches to over a foot long; bright green, well flavored. Stock enjoy this grass. It could be profitably cultivated towards the mountains on rich slopes, or in moist valleys. It seems to have no special choice of habitat, however. I have seen it from 2 inches to over 18 inches high at the rocky summit of Mount Helena, and it grows over 2 feet high in one corner of my ranch in Sand Coulee. (Sand Coulee is a large valley of the plains near the falls of the Missouri River; altitude about 3,400 feet.) This grass is also common in the Bird-tail Mountains, portions of the Belt Mountains, and in the ranges south and west towards the Idaho line.

Muhlenbergia glomerata (Drop-seed Grass, Muhlenberg's Grass).—There seems to be no local name for this or the other Muhlenbergias found here. Ask a stockman what it is, his answer will be, "Oh, it's a kind of Foxtail, I guess." This species has been observed in the counties of Chouteau, Cascade, Deer Lodge, Silver Bow, and Beaver Head. But the only locality in which I have seen it abundant is at Warm Springs, in the extreme southeast corner of Deer Lodge County. It grows freely in the warm marshy ground about the springs. It extends by slender, brittle root-stocks, and in this county (Cascade) is much affected by *Ustilago Montanensis*, Ellis & Holway, which aborts the panicles of at least half the culms. Cattle eat the grass readily, and it seems to be a desirable one for cultivation, as it would yield a heavy crop of very good hay. It is a late-flowering species, producing great quantities of nutritious seeds. It seems to flourish just as well in ordinarily dry situations as in wet ones.

Phleum alpinum, L. (Native Timothy, Cat's-tail Grass, also called "Mountain Timothy").—Plentiful in all the mountain regions, along streams, openings in pine forests, and in the moister "parks." A valuable grass and much esteemed for hay. Seldom over 20 inches high, but sometimes upwards of 2 feet; culms often quite leafy.

Phleum pratense, L. (Timothy, "Tame" Timothy).—Can hardly be classed with the native pastoral resources, but has been introduced to a considerable extent. In the southern and western parts ample irrigation is found necessary to its successful culture. In the northern and eastern parts irrigation is not thought of. This year I saw 3 acres of splendid timothy 4 feet high, standing thickly on the top of the highest hill near Great Falls. The field, only "sod-breaking,"

is the property of Mr. John Glass. Timothy has become naturalized in the mountains about Helena. Isolated patches of it are frequently found in the Belt Mountains. Rev. F. D. Kelsey, the well-known "Helena botanist," reports it as having run wild in the mountains about Rimini. It grows sparingly along Black-Tail Deer Creek, near Dillon, and along the Red Rock River, near Spring Hill (Allerdice P. O). This plant is found in such unusually out-of-the-way places and is so widely distributed that some have suggested the possibility of its being just as much native to this region as *P. alpinum.*

Sporobolus cryptandrus, Gr. (Drop-seed Grass).—Along sandy banks of streams; also in cultivated soil. Very prolific, soon taking possession where allowed. Cattle and sheep eat it down close whenever they can get at it. Several other species occur, but appear to be of little or no value. *S. depauperatus*, Torr., is found throughout; very abundant in some localities, especially in Beaver Head County, where it is abundant on the bottoms mixed with grama and other grasses.

Deschampia cæspitosa, Beauv. (Hair-Grass).—This beautiful and variable grass is found throughout, but constitutes a regular forage plant in very few localities. It produces many leaves and culms from the tufted base, which are eagerly eaten by horses, cattle and sheep in the spring and early summer. It grows in a great variety of soils and can bear considerable drought. In a few isolated localities are stretches of valley several miles in extent, fine meadow lands, where this species, and grama grass, and *Poa tenuifolia* grow in about equal proportion.

Danthonia unispicata, Munro (Wild Oat-Grass).—Several species occur, but this is the only one I have found in abundance. It grows on the higher "bald" mountain slopes, often being the principal grass. Growing, in general appearance, it reminds one of a rich growth of grama grass; but the single terminal, erect spikelet is a peculiarly plain distinguishing feature. I believe this grass to be of almost as much importance on some of the higher mountains in proportion to the area of its habitat as the grama grass on the plains. I have had horses "picketed" days together in mountain "parks" where this was almost the only grass. They liked it and did well. In the herbarium of Mr. Robert S. Williams, of Great Falls, are specimens of *D. Californica* and *D. intermedia*, which he says are common in the main range at the head of the North Fork of Sun River.

Agrostis scabra, Willd. (Thin-Grass, Bent-Grass, also called "Foolhay").—Everywhere. In comparatively moist spots it sometimes covers many acres.

Agrostis exarata, Trin. (Bent-Grass).—I have never heard a local name for this common and valuable grass. It is variable in size and appearance, but under proper conditions grows over 2 feet high. Culms numerous, leafy, especially at the base; leaves flat, erect, the lower ones 2 to 5 inches long. It grows about springs and along streams, and ought to be cultivated.

Agrostis alba, L. (Bent-Grass, Red-top).—Abundant throughout in well-watered localities; often growing 3 feet high. An excellent grass for meadow or pasture.

The eastern form, *A. vulgaris* (Red-top), has been introduced sparingly into cultivation. It is also found here and there along the various lines of railroad, quite distinct in appearance from the native plant. It does best in low grounds, and like the native species bears considerable moisture. The latter is frequently found almost

choking some of the small shallow brooks or creeks. All kinds of stock thrive upon these grasses.

Ammophila longifolia, Benth. (Sand-Grass).—Throughout, but apparently most common in the northern and eastern parts; chiefly on dry hillsides and in sandy soil on the benches and bottoms. A very useful species, serving to bind loose soil and prepare the way for more nutritious forms; one to 5 feet high, rather stout. Although it has strong, creeping root-stocks it is easily exterminated when desirable; simple plowing and harrowing a few times checks its growth. For this reason it can be safely recommended as a truly valuable pioneer grass for reclaiming unproductive, sandy wastes. It is sometimes cut for hay, but stock will not eat it till compelled, unless it is cut young. It often grows in small circular patches, at other times irregularly covering large areas. It turns yellowish-brown in August or September, and may be distinguished from other vegetation at long distances.

Deyeuxia Canadensis, Beauv. (Reed Bent-Grass).—Common with *Phalaris arundinacea;* growing to nearly the same height; leaves long and numerous. It is worth cultivating, as are the following members of the genus:

Deyeuxia Suksdorfii, Scribner.—At a first glance one might take this for an *Agrostis*. Professor Scribner, in his interesting paper, "Agricultural Grasses of Central Montana," mentions it as being rather plentiful along Smith's River Cañon "on dry but rich limestone soil." Rev. F. D. Kelsey, of Helena, found it growing in sandy soil at the "Warm Springs" near Helena. (This is not the Warm Springs in Deer Lodge County, where the Territorial Insane Asylum is located.) This grass has every appearance of being the kind to cultivate. The slender, leafy culms are upwards of 2 feet high, bearing a densely-flowered panicle of a light straw color which is sometimes faintly and delicately tinged with rose-purple. The leaves are 2 to 8 inches long, and in my specimens 2 to 5 lines wide, and straight, growing numerously from the base. The plant grows in clumps or bunches.

Deyeuxia neglecta, Kth. (Reed Bent-Grass).—Common throughout in wet places with *D. Canadensis* and *Phalaris arundinacea*. It is of about the same height as the latter, but the leaves are mostly narrow and involute.

Bouteloua oligostachya, Torr. (Mesquite, Grama-Grass, "Buffalo-Grass").—Is not called mesquite here. I have never seen true buffalo-grass in Montana. It has been reported from several localities, but I have not seen specimens. The grama-grass equals the "blue-joints" in nutritive qualities, and doubtless covers as many acres, if not more, in this Territory, rarely growing tall enough to be cut for hay. It occurs sparingly in the foot-hills, but on the open plains holds its own; often 18 inches high, where growing luxuriantly. Leaves mostly at the base, very numerous, short and crisp, inclined to be curly. Average height of the plant (culms) as it grows on the range is about 8 inches. The plants usually grow thickly together in cushion-like patches, and so form a more or less dense turf according to the nature of the soil. In many parts stock subsist almost the entire year, mainly on this species. They readily fatten upon it, even in winter. If pastured too closely for several years by sheep it loses its vitality and becomes very sparse. Improves wonderfully in size when growing accidentally in cultivated ground. The whole plant becomes stronger and more robust; the culms seems to be more leafy and at-

tain a height of fully 18 inches. It seems to me that if properly cultivated this grass might become valuable for hay, and it certainly would make excellent pasture. Although most abundant on the benches, it grows well in fairly moist valleys, but too much wet injures it.

Phragmites communis, Trin. (Reed).—Common along streams and in marshy ground throughout. Of no apparent value as food and usually considered useless. In England and on the Continent in some parts, the stems are much used for thatching the roofs of farm-houses, barns, out-buildings, and stacks. It is highly esteemed for this purpose, making a durable, water-proof roof. I have seen roofs of reeds over a hundred years old in good repair; of course spots on these roofs had been rethatched occasionally. Reeds might be used here for similar purposes, particularly in regions where lumber is dear and shingles a luxury.

Kœleria cristata, Pers. ("June Grass").—Like the grama and "blue-joint" grasses, this is an important species on the ranges of Montana. It appears to be most abundant in the central, northern, and eastern parts. It is not confined to the plains, but may be found frequently on high mountain ridges in company with *Poa Californica*, *P. Cusickii*, and *P. andina*, where it frequently attains a growth of 2 feet high; whereas, on the plains, excepting in moist situations, it only averages about a foot in height. It begins to flower towards the end of May, and continues till about the end of June. Grows in tufts, and in vigorous mountain specimens these tufts are developed into small bunches. An excellent grass in every respect for open pasture and for hay.

Eatonia obtusata, Gray, var. *robusta*, Vasey. (Eaton's Grass).—A good grass, occurring most abundantly in the southern parts. Rather common along the water-courses of Beaver Head and Madison Counties. Have never found it in the northern part. Very fine specimens in my herbarium were collected by Rev. F. D. Kelsey at Blue Cloud, near Helena.

Eragrostis major, Host.—Is an introduced weed chiefly remarkable for the very offensive odor it emits, and even leaves upon one's hands after handling it. Not yet common.

Melica spectabile, Scribner (Melic Grass).—This is common in the mountains, but can scarcely be considered of pastoral value.

Melica bulbosa, Geyer (Bulbous Melic Grass).—Common in various parts of northern Montana, and doubtless occurs throughout. Never found it in the mountains. It grows plentifully in Sand Coulee, 5 miles from Great Falls. Might become a useful hay grass by cultivation. Culms 2 to 4 feet high, eaten with avidity by stock. The bulbous roots contain a considerable quantity of sugar.

Distichlis maritima, Raf. (Spike-Grass, Salt-Grass, "Quack-Grass").—Common, especially in alkaline soils. Grows from 3 inches to about 2 feet high. Leaves very prevalently attacked by a rust. Stock seem to avoid this *weed*, and ranchmen hate it.

Poa tenuifolia, Nutt. (Meadow-Grass, "Bunch-Grass," "Red-top").—A finer grass for cultivation on dry plains or in regions subject to drought can not be found. Grows in all parts of the Territory, chiefly on the high benches. But it also grows in the rich valleys, where it attains a good height and yields a great quantity of superior hay. Commonly associated with *Kœleria cristata*. As growing, the radical tufts of the two species have a very similar appearance.

Poa lævis, Vasey.—Reaches a height upwards of 2 feet. Found

chiefly along streams and in springy localities. It affords a valuable addition to the pastoral grasses of well-watered regions.

Poa nemoralis, L.—This grass has no particular habitat. It is frequently associated with *P. lævis*. Also abundant in the mountains. In 1887 I collected very fine specimens at the summit of Mount Helena, where cattle and horses belonging to the city below were grazing upon this and other grasses already spoken of.

Poa cenisia, All.—Is another valuable species abundant in the mountains and foot-hills.

Poa Cusickii, Vasey, *P. andina*, Nutt., and *P. Californica*, Vasey, are commonly found together. They are often accompanied by *Kœleria cristata* and *Festuca ovina*. These species growing together form a dense turf in some localities in the foot-hills and on the mountain slopes and ridges. The amount of pasturage they afford is very great.

Glyceria arundinacea, Kth., var. *aquatica*, Smith (Reed Meadow Grass, "Water-Grass").—Very common throughout in low, wet places; often growing in water. Leafy and tall, 3 to 5 feet high. Cows delight to feed in a patch of this grass.

Glyceria pauciflora, Presl.—Occurs in many localities, but, so far as I have observed, chiefly from the vicinity of Helena southward and westward. This is also an excellent grass.

Glyceria nervata, Trin.—Is to be found everywhere in situations moist enough for its growth. In some localities it contributes largely to the native forage.

Glyceria distans, Wahl.—Common. It is readily eaten by stock. The variety *airoides*, Vasey, is a common form along the Sun River Valley, and in Cascade County generally.

Festuca scabrella, Torr. (Great Bunch-Grass).—On the higher foot-hills and mountain slopes this is the predominant species. Growing in bunches often several feet in diameter, the culms rise to a height of 3, 4, and even 5 feet. In July and August this grass is cut for hay. Although it is good for this purpose, it is considered not nearly so good as "blue-joint." It is one of our most important and characteristic mountain and foot-hills forage plants.

Festuca ovina, L. (Sheep's Fescue, Lesser Bunch-Grass).—This grows with the last on the foot-hills, but extends to a much lower altitude. Very variable. May be found from a few inches with only one or two culms, up to more than 3 feet high with very many slender culms and leaves, forming dense, thick bunches. This species is the equal if not the superior of the great bunch-grass, and has the advantage of being equally as palatable to sheep as it is to horses and cattle. Makes splendid hay.

Bromus Kalmii, Gray, *B. breviaristatus*, Thurb., and *B. ciliatus* are all common; the first two in the mountains, where they sometimes form large meadows. They are then a beautiful, luxuriant sight; but stock do not seem to care for any of these grasses. I never saw them cut for hay.

Agropyrum glaucum, R. and S. ("Blue-joint," "Blue-stem").—This is the celebrated "blue-joint" of the Northwest. More valued for hay than any other species, and its yield per acre under favorable conditions is something remarkable, viz, over 3 tons. It often yields 2 tons, and under the most ordinary conditions yields over a ton. These crops are secured on native, uncultivated sod.

Agropyrum divergens is perhaps the next in general value. It grows in bunches, and for that reason has received the customary popular name of "bunch-grass." Sometimes attains a height of

nearly 4 feet. Most luxuriant in the lower foot-hills, but is common on the rocky bluffs and knolls of the plains, frequently occurring with *Aristida purpurea*. The culms, though slender, are very stiff and brittle. Stock avoid this grass in summer, but in winter in certain localities it is their chief support; hence it is considered an excellent species for winter ranges. Even sheep eat it then.

Other species more or less abundant are *A. caninum*, Reich., *A. violaceum*, *A. repens*, Beauv., and *A. tenerum*, Vasey. The last is of considerable importance in some parts.

Hordeum jubatum, L. (Foxtail Grass, Squirrel-tail Grass).—Throughout, mostly growing in waste places. Very variable; some of its forms are hardly distinguishable from *H. nodosum*. Regarded as a good-for-nothing weed. Often grows in patches of 5 to 10 acres large.

Elymus condensatus, Presl. (Lyme-Grass, Wild-Rye, Rye-Grass).—By the last name it is chiefly known here. It is of no great value, but abundant throughout along streams, in bottoms, and up steep coulée sides. Four to 8 feet or more high. The coarse stems, like those of *Phragmites communis*, would make a good thatch. Occasionally cut for hay. Must be cut young or stock will hardly eat it. Fed too long at a time to horses it causes them to "scour."

Several other species occur, but they are of even less value than this. *E. sitanion*, Schult., in some of the southern localities is almost as great a nuisance as *Hordeum jubatum*.

CONCLUDING REMARKS.

It will be seen from the foregoing notes that Montana is blessed with a great variety of nutritious grasses adapted to all kinds and conditions of soil. On the plains *Poa tenuifolia*, *Kœleria cristata*, *Stipa comata*, *Bouteloua oligostachya*, *Agropyrum glaucum*, and *Agropyrum divergens* are the leading species. Every one of them fills an important niche in pastoral vegetation. In the foot-hills *Festuca ovina*, *Poa tenuifolia*, *Agropyrum divergens*, and *Agropyrum tenerum* take the lead. On the higher foot-hills and mountain slopes *Festuca scabrella*, *Agropyrum caninum*, and *Poa tenuifolia* are the chief. Still higher are the *Poas*, of several species predominating. Along water-courses and in wet places the leading species are *Phalaris arundinacea*, *Deyeuxia neglecta*, *Deyeuxia Canadensis*, *Agrostis exarata*, *Glyceria arundinacea*, var. *aquatica*, and *Poa lœvis*.

Grasses are not the only forage plants in Montana. Such species of Carex as *C. filifolia*, *C. stenophylla*, and *C. Douglasii*, form an important part of the diet of stock on the benches; while *C. filiformis*, *C. utriculata*, *C marcida*, and several other species are as important in the moist valleys and sloughs.

It has been estimated roughly that in northern and eastern Montana from 3 to 5 acres of grass land is sufficient for a horse or steer for one year, and that about 1 acre is sufficient for a sheep. In the south and southwestern parts from two to four times this amount is necessary. But any of these figures, if correct, speak volumes for the pastoral resources of this Territory.

FIG. 1. REIMARIA OLIGOSTACHYA.

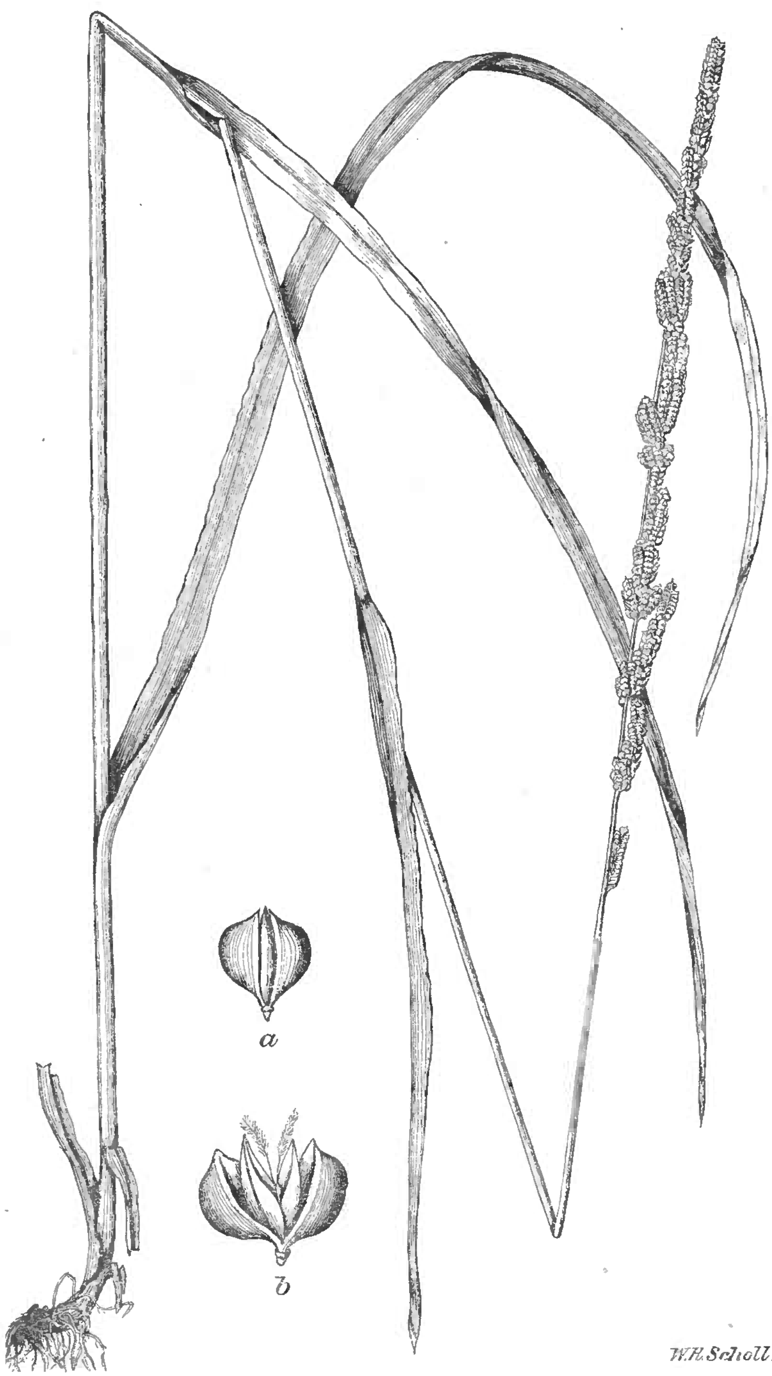
FIG. 2. PASPALUM VAGINATUM.

PASPALUM DISTICHUM.

SETARIA VIRIDIS (GREEN FOXTAIL).

PLATE IV.

OPLISMENUS SETARIUS.



BECKMANNIA ERUCÆFORMIS (SLOUGH GRASS).

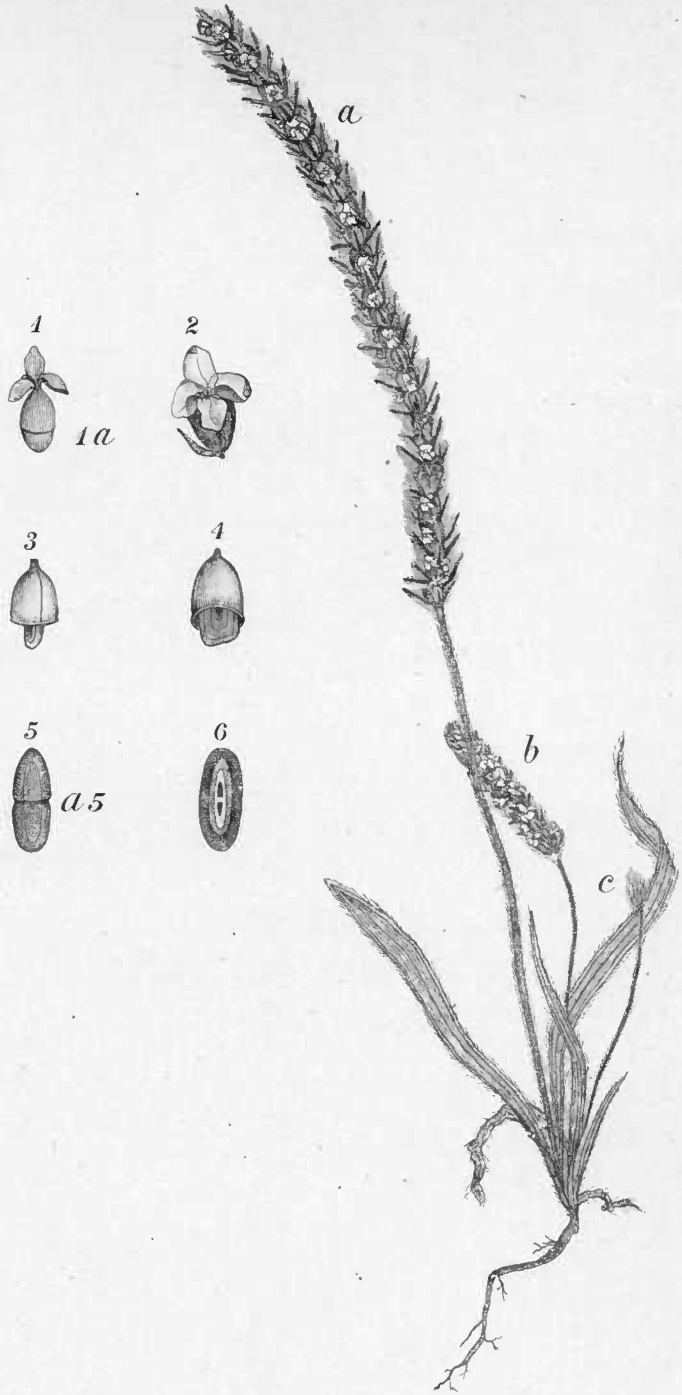
ANTHENANTIA RUFA.

AMPHICARPUM PURSHII.

LEERSIA VIRGINICA (RICE-GRASS).

POA ANDINA.

AGROPYRUM GLAUCUM (COLORADO BLUE STEM).



T. W. Anderson, del. ad nat.

PLANTAGO PATAGONICA, JACQ. (WESTERN PLANTAIN).

Figs. 1 to 6 greatly enlarged.

W. Anderson, del. ad nat.

LYGODISMIA JUNCEA.

F. W. Anderson, del. ad nat.

SOLANUM TRIFLORUM (WILD POTATO).

REPORT OF THE SECTION OF VEGETABLE PATHOLOGY.

SIR: Having been appointed Chief of the Section of Vegetable Pathology on the 1st of November, 1888, I have the honor to present herewith my first report.

During the past year, and since the publication of the Annual Report for 1887, the Section has issued four bulletins as follows:

Bulletin No. 5 on the experiments made in 1887 in the treatment of the downy mildew and black-rot of the grape-vine, together with a chapter on apparatus for applying remedies for these diseases. This bulletin was issued early in May, 1888, and contains 113 pages, and 24 illustrations. The first 36 pages embody the reports of four special agents, who, under the direction of the Section, and with your sanction, conducted a series of experiments at Vineland, N. J.; Charlottesville, Va.; Neosho, Mo.; and Denison, Tex. Part II of the Bulletin contains the reports of more than 200 grape-growers who experimented with the sulphate of copper remedies, while Part III embodies the results of observations made in 1887 in the treatment of the downy mildew in France.

Bulletin No. 7 on the history and progress of black-rot of grapes in America is for the most part a translation of a paper by Viala & Ravaz, of Montpellier, France,* and embodies the results of observations made in this country in 1887 by P. Viala and F. L. Scribner.

Bulletin No. 8 relating to some of the practical work of the Section, including papers on potato-scab, foot-rot of the orange, extracts from correspondence, etc., was issued as a joint publication with one of a similar nature prepared by Dr. George Vasey, Chief of the Botanical Division.

Bulletin No. 9 on peach yellows, embodying the results of investigations made by Erwin F. Smith, a special agent appointed for this work, contains 200 pages, 9 colored maps, 6 lithographic and 37 photo-engraved plates. A short abstract of this bulletin will be found in the accompanying pages of this report.

The correspondence of the Section is constantly increasing, and as it is a most important means of disseminating useful information every effort is made to give it the attention it deserves.

During the year many new and valuable additions have been made to the herbarium, and the number of permanent microscopic mounts of fungi has also been materially increased.

Since the middle of July Mr. F. W. Anderson, a special agent of the Section, has been at work in Montana collecting specimens and

*Extrait du Progress Agricole et Viticole, Sept., 1888.

making observations on the fungi of that region. In this work particular attention has been given to the fungi of grasses, and arrangements have been made for distributing these among the various Agricultural Colleges and Experiment Stations.

The following report, prepared at my request by Mr. Anderson, shows the nature of the work in which he is engaged.

REPORT OF F. W. ANDERSON.

From the middle of July, 1888, to the close of the collecting season, I was actively engaged in collecting specimens of phanerogams and fungi for the Botanical Division, and during that time several important parts of the Territory were visited. More special attention was given to the parasitic fungi than to any other part of the work. In fact, enough has been done in this line to justify the publication of a "Preliminary List of the Parasitic Fungi of Montana."

In the prosecution of this work it has been my constant effort to learn as much as possible of the economic importance of every species found—the relation borne by the fungus to its host and by the host to the lower animals and to man. In this way I have been able to make at least a few notes worthy of careful consideration by Experiment Station authorities as well as by those who make farming their occupation.

In the list of fungi, which at this writing is not yet completed, there will be over 200 species enumerated, nearly a dozen of which are new to science. One I would call special attention to here is a new *Ustilago*, or smut, on *Muhlenbergia*, called by Messrs. Ellis and Holway, who described it in the Journal of Mycology, *Ustilago Montaniensis*. This fungus is very common here and causes most wretched changes in the panicles of the host. As soon as the grass is old enough to develop the first head or spike, the fungus has already matured; and as the grass shoots up, developing its numerous spikes, each one in an affected plant will be found completely filled by the black-looking spores of the *Ustilago*. It would seem from this that the spores grow within the tissue of the host while it is very young, and in their own development keep pace with that of the host.

With the list will be figures of the new species and as full notes as I have been able to collect about each. In Montana a collector of parasitic fungi can not fail to be impressed by the great comparative number of species representing the *Uredineæ*, or rusts. They are to be found everywhere in one stage or another; on the tops of the highest mountains; on the driest of plains and in the most moist of valleys. Fortunately for growing vegetation, most of the species are apparently harmless, causing no injury to living tissue removed from actual contact with them.

In concluding this brief note I would express my thanks to my friend, the Rev. F. D. Kelsey, of Helena, Mont., for the many valuable notes and specimens of fungi and other plants he has sent me from time to time as well as for his open hospitality and the freedom of his valuable collection of Montana plants, whenever it has been my good fortune to work in his locality.

F. W. ANDERSON,
Special Agent.

B. T. GALLOWAY,
Chief of Section.

A.—EXPERIMENTS IN THE TREATMENT OF GRAPE-VINE DISEASES MADE IN 1888.

[Extracts from reports of special agents and others.]

As heretofore extensive experiments in the treatment of the fungous diseases of the vine have been conducted by special agents located in New Jersey, Virginia, and Missouri, as well as by private individuals in nearly every State in the Union. The information acquired through these will form the basis of a special report soon to be published. As the edition of this bulletin will be comparatively limited, the following extracts from a few of the more important reports are here given.

On May 5, 1888, the following letter was sent to each of the special agents, and at the same time a circular, which is given in full below, was distributed among grape-growers with the request that they follow the instructions contained therein.

I.—LETTER OF INSTRUCTION TO AGENTS.

DEAR SIR: I send herewith several formulas to be used in the treatment of vine diseases. I desire the experiments to be conducted in a manner similar to those of last year, of course making such changes in detail as former experience has made necessary.

The remedies to be experimented with are eau celeste, Bordeaux mixture, and sulphatine.

1. EAU CELESTE, AUDOYNAUD PROCESS:

Dissolve 1 pound of sulphate of copper in 2 gallons of hot water; when completely dissolved and the water has cooled, add $1\frac{1}{2}$ pints of commercial ammonia (strength 22° Baume); when ready to use dilute to 22 gallons. The concentrated liquid should be kept in a keg or some wooden, earthen, or glass vessel.

2. EAU CELESTE, MODIFIED FORMULA:

Sulphate of copper	pounds..	2
Carbonate of soda	do....	$2\frac{1}{2}$
Ammonia (22° Baume)	pints..	$1\frac{1}{2}$
Water	gallons..	22

Dissolve the sulphate of copper in 2 gallons of hot water; in another vessel dissolve the carbonate of soda in a similar manner; mix the two solutions, and when all chemical reaction has ceased add the ammonia; then dilute to 22 gallons.

3. BORDEAUX MIXTURE:

Sulphate of copper	pounds..	6
Lime	do....	4
Water	gallons..	22

Dissolve the copper in 16 gallons of water; in another vessel slake the lime in 6 gallons of water; when the latter mixture has cooled pour it slowly into the copper solution, care being taken to mix the fluids thoroughly by constant stirring.

4. SULPHATINE, THE ESTÉVE PROCESS:

Mix 2 pounds of anhydrous sulphate of copper with 20 pounds of flowers of sulphur and 2 pounds of air-slaked lime. The proportions may be varied.

Respectfully,

NORMAN J. COLMAN,
Commissioner of Agriculture.

II.—CIRCULAR DISTRIBUTED AMONG GRAPE-GROWERS.

[United States Department of Agriculture. Section of Vegetable Pathology.]

Treatment of the downy mildew and black-rot of the grape.

To the Vineyardists of the Country:

The results of experiments in 1887 have fully demonstrated the value of sulphate of copper (blue-stone) over all other remedies in combating the mildew, and the results of many chemical analyses of the fruit and parts of vines treated with copper compounds have clearly shown that there is no danger to health attending their application. The only precaution advised is not to apply them near the time (within fifteen days) of the vintage.

In their employment the fact must be kept in mind that their action is only preventive, therefore their application should be made early in the season, from the latter part of May to the end of June. Subsequent applications act only in so far as they serve to check the spread of the disease. The amount of the fluid compounds required to treat an acre of vines will depend largely upon the kind of pump and spraying nozzle used to supply them, and upon the extent of growth of the vines themselves; the amount may vary from 20 to 35 gallons.

The following are the formulæ of the remedies which so far have given the best results. An account of the results of trials you may make with one or more of them is earnestly desired, and a blank form for making up a report for the use of the Department in future publications will be sent you upon the receipt of the addressed postal card inclosed herewith.

Liquid remedies.

(1) *Simple solution of sulphate of copper.*—Dissolve 1 pound of sulphate of copper in 25 gallons of water. Spray the vines with a convenient force-pump having a nozzle of fine aperture. Less lasting in its effects than the next, as it is easily washed off by rains.

(2) *Eau celeste, blue-water* (*the Audoynaud process*).—Dissolve 1 pound of sulphate of copper in 3 or 4 gallons of warm water; when completely dissolved and the water has cooled, add 1 pint of liquid ammonia; then dilute to 22 gallons. The concentrated liquid should be kept in a keg or some wooden vessel and diluted when required for use. Apply the same as in case of simple solutions.

(3) *Eau celeste, modified formula:*

Sulphate of copper	pounds..	2
Carbonate of soda	do....	2½
Ammonia (22° Baume)	pints..	1½
Water	gallons..	22

Dissolve the sulphate of copper in 2 gallons of hot water; in another vessel dissolve the carbonate of soda in a similar manner; mix the two solutions, and when all chemical reaction has ceased add the ammonia; then dilute to 22 gallons.

(4) *Bordeaux mixture.*—Dissolve 6 pounds of sulphate of copper in 16 gallons of water; in another vessel slake 4 pounds of lime in 6 gallons of water. When the latter mixture has cooled pour it slowly into the copper solution, care being taken to mix the fluids thoroughly by constant stirring. Well made pumps with specially constructed nozzles are required for the application of this compound. The Vermorel apparatus and the Eureka sprayer are well adapted for vineyard use, and are especially constructed for applying the various liquid preparations containing sulphate of copper.

Powders.

(5) *Sulphatine, the Estève process.*—Mix 2 pounds of anhydrous sulphate of copper with 20 pounds of flowers of sulphur and 2 pounds of air-slaked lime. The proportions may be varied.

(6) *David's powder.*—Dissolve 4 pounds of sulphate of copper in the least possible amount of hot water, and slake 16 pounds of lime with the smallest quantity of water required. When the copper solution and slaked lime are completely cooled mix them together thoroughly; let the compound dry in the sun; crush and sift. Apply with a sulphuring bellows furnished with an outside receptacle for the powder. The copper coming in contact with the leather will soon destroy it.

Both these powders ought to be procured from the manufacturer prepared ready for use.

III.—EXPERIMENTS AT VINELAND, N. J.

The experiments were conducted at this place by Col. A. W. Pearson, and the vines treated were of the Concord variety. The applications were made with the Eureka sprayer and the Riley cyclone nozzle, May 29, June 14, June 21, July 2, July 11, and August 8. Black-rot appeared on the leaves of the untreated vines on June 2 and on the fruit of the same vines June 27. Rain and fog were frequent during July, and by the last of the month all Concord grapes unprotected were totally destroyed. There was also considerable rot on the treated vines. Throughout the season the rot continued, only ceasing when there were no more grapes to rot. Downy mildew (*Peronospora viticola*) first appeared epidemically about August 10, but as the season was cool and moist it occasioned no serious injury.

Concerning the efficacy of the remedies for black-rot Colonel Pearson concludes his report as follows:

On the untreated vines the grapes are almost totally destroyed. One or two sound berries may be found remaining on a few clusters, but at least nine-tenths of

the bunches show only a mass of dried and shriveled victims of the disease. On all the vines treated with the remedies prevention of rot is perceptible, but on none of them is it strikingly so, except on those sprayed with the Bordeaux mixture. Here, the treated rows have many nearly perfect clusters, which show but one or two rotted berries each. Where grape clusters were wet with the Bordeaux mixture *early* and *often* they were saved from rot. Where not thus sprayed they were entirely destroyed. The following table shows the yield of a number of treated and untreated vines; the berries in all cases were gathered from adjacent rows and carefully weighed:

Description.	Yield of grapes.	Description.	Yield of grapes.
	Pounds.		*Pounds.*
Section 3:		Section 5:	
13 vines treated with Bordeaux mixture	80	14 vines treated with eau celeste No. 2	14
13 vines untreated	$2\frac{1}{4}$	14 vines untreated	4
Section 4:		Section 6:	
13 vines treated with eau celeste No. 1	$6\frac{1}{2}$	25 vines treated with sulphatine	20
13 vines untreated	2	25 vines untreated	4

The following experiments made by Colonel Pearson are interesting, as they show conclusively that the rot can be prevented by the Bordeaux mixture:

In a vineyard untreated by rot preventives I applied several thousand grape bags, beginning before the grapes bloomed. On successive rows of Concords I put 200 bags every day (dating the bags), beginning before the vines were in blossom, and continuing until grape-rot appeared epidemically. On July 30 the bagged grapes were inspected, and in the bags applied until June 22, inclusive, it was found that they were generally free from rot, while those bagged on June 23 and subsequently were badly rotted.

This experiment indicates that the invasion of the disease occurred seriously after June 22, a. m., when the bags for that day were applied, and *before* June 23, a. m., when the bags for that day were put on.

On June 23, p. m., was a thunder-storm and slight spatter of rain. If this rain had come *before* the grapes were bagged on June 23, the invasion of the rot might be accounted for at that date through the supervention of the rain. But the grapes were bagged in the morning, during intense heat and drought, and the rain was not until afternoon.

Extended inspection of these bagged grapes made recently discovers the interesting fact that the infection of black-rot may enter the grape before it blossoms. The clusters bagged early are generally safe from rot, but there is occasionally seen in them one or two berries destroyed by the first invasion of the fungus. There is just enough evidence to prove that the infection probably occurred as stated.

After removing bags from grape clusters on August 1, I tried if these might be protected from rot during the rest of the season by an application of the Bordeaux mixture on August 4.

It was raining at the time the bags were taken off on August 1; a few rotted grapes appeared on these clusters on August 12.

I then took the bags from many clusters and sprayed these immediately with the Bordeaux mixture. At the same time I left some clusters (from which the bags were removed) unsprayed. The latter showed in a few days the spots indicative of infection by the rot germs; the former remain healthy and are now (September 24) ripe.

IV.—EXPERIMENTS AT NEOSHO, MO.

The experiments in Missouri were conducted at Neosho by Mr. Hermann Jaeger. The first applications of eau celeste, Bordeaux mixture, and sulphatine were made from May 1 to May 10. The second applications were made from June 4 to June 10. Black-rot first appeared on the foliage of both treated and untreated vines—but less on the former—on June 8. June 12 to 15 a third application with the same remedies as before was made, care being taken to thoroughly

spray all the fruit; June 23, a fourth application was made. On July 1 a thorough examination of all grapes was made and it was found that Martha, Concord, Telegraph, Gœthe, and other Labrusca and European hybrids had from 30 to 40 per cent. of their fruit destroyed by black-rot on all untreated vines. The same varieties treated with eau celeste had from 20 to 30 per cent. of their fruit destroyed, while those treated with Bordeaux mixture had hardly 15 per cent. destroyed. Ten vines thoroughly sprayed with the Bordeaux mixture on the 23d of June had not lost over 8 per cent. of their fruit from rot. On August 1 all the vines were examined and the following table was prepared:

Variety.	Per cent. destroyed by black-rot.			Variety.	Per cent. destroyed by black-rot.		
	No treatment.	Eau celeste.	Bordeaux mixture.		No treatment.	Eau celeste.	Bordeaux mixture.
Perkins	1	1	.5	Noah	30	....	1 5
Ives	2	1.5	1	Missouri Riesling	1.5	.4	.2
Martha	40	30	26	Hermann	40	30	25
Concord	50	35	25	Norton	.4	.3	.1
Catawba	55	40	35	Neosho	5	4	2
Telegraph	65	55	....	Linceumii No. 9	75	....	....
North Carolina	75	70	65	Racine	60	50	40
Delaware	30	18	3	Linceumii Nos. 13, 43	0	0	0
Herbemont	75	....	70	Æst. x Rupestris 70	2	2	1
Gœthe	70	60	60	Rupestris type	0	0	0
Elvira	.8	.6	.3				
Uhland	20	15	....	Average	31.7	18.8	16.8

From August 25 to August 30 all vines were again treated. On September 10 the vines were again examined, but as the earlier varieties had been gathered, a comparison could only be made between the late grapes, which were of the Æstivalis species; these, however, on both treated and untreated vines, were quite as sound as when examined the month before.

Concerning the efficacy of the copper remedies for downy mildew (*Peronospora viticola*) Mr. Jaeger says:

> There is no doubt that Elvira, Delaware, and all vines that are usually seriously damaged by mildew here were greatly benefited by the remedies, and their vigorous growth, matured to the tips, promises a better crop next season than ever before.

Mr. Jaeger concludes his report as follows:

> With these remedies (especially the Bordeaux mixture) applied *early* and *often*, we can certainly reduce the ravages of black-rot, and it is quite possible that we may yet succeed in preventing it with as much certainty as mildew.

V.—EXPERIMENTS AT CHARLOTTESVILLE, VA.

Mr. H. L. Lyman conducted the experiments at Charlottesville, using nine different remedies, as follows:

1. Sulphatine:
   - Anhydrous sulphate of copper .... pounds.. 2
   - Flowers of sulphur .... do.... 20
   - Air-slaked lime .... do.... 2
2. Bordeaux mixture (*a*):
   - Sulphate of copper .... pounds.. 8
   - Lime .... do.... 10
   - Water .... gallons.. 20

3. Bordeaux mixture (*b*):
   Sulphate of copper....pounds.. 6
   Lime....do.... 4
   Water....gallons.. 20
4. Eau celeste (*a*):
   Sulphate of copper....pound.. 1
   Ammonia....pint.. 1
   Water....gallons.. 22
5. Eau celeste (*b*):
   Sulphate of copper....pound.. 1
   Ammonia....pint.. 1
   Water....gallons.. 44
6. Eau celeste, with carbonate of soda (*c*):
   Sulphate of copper....pounds.. 2
   Carbonate of soda....do.... 1
   Water....gallons.. 44
7. Eau celeste, with carbonate of soda (*d*):
   Sulphate of copper....pounds.. 2
   Carbonate of soda....do.... 2
   Water....gallons.. 22
8. Eau celeste, with carbonate of soda (*e*):
   Sulphate of copper....pounds.. 4
   Carbonate of soda....do.... 8
   Water....gallons.. 22
9. Ammoniacal carbonate of copper solution:
   Carbonate of copper....ounces.. 3
   Liquid ammonia....quart.. 1
   Water....gallons.. 22

Excepting No. 1, which was purchased ready for use, the foregoing preparations were prepared in the usual manner,* and were applied with the Vermorel and Eureka sprayers.

The following table shows the results of the treatments as indicated at the time the fruit was gathered:

Preparation used.	When applied.						No. of vines treated.	Treated vines. Loss from—		Untreated vines. Loss from—	
	May.	May.	June.	June.	July.	Aug.		Mildew.	Black-rot	Mildew.	Black-rot
									Per cent.		*Per cent.*
No. 1	11	31	24	......	20	......	142	None	15	Heavy	25 to 30
No. 2	11	......	2	......	5	......	138	...do	5 to 10	...do	60 to 65
No. 3	12	......	2	......	5	......	143	Very little.	10 to 12	Very little.	33⅓
No. 4	18	......	5	22	13	......	142	...do	5	Heavy	33⅓ to 50
No. 5	18	......	5	22	13	9	273	...do	10 to 18	...do	40 to 45
No. 6	21	......	5	22	10	......	282	None	5 to 8	Consid'ble.	18 to 20
No. 7	21	......	5	22	10	......	139	...do	3 to 5	...do	15 to 20
No. 8	21	......	3	22	10	......	145	...do	3 to 5	...do	15 to 20
No. 9	30	......	18	......	10	......	137	...do	20 to 25	...do	50 to 60

Varieties treated.

No. 1. Wilding, Etta, Grein's Golden, Missouri Riesling, Uhland, Empire State Lutie, Triumph, Marion, Rebecca, Montefiore.

No. 2. Roger's Hybrids, Ricketts, Grein's Seedlings, Concord, Moore's Early, Cottage, Worden, Delaware, Lady Pocklington, Jefferson, Montgomery, Ives, Hartford, Wyoming Red, Vergennes, Duchess, Prentiss, Martha.

No. 4. Catawba, Elvira, Bacchus, Gœthe, Delaware, Lindley, Lady Washington, Salem, Martha.

No. 5. Cottage, Lindley, Black Eagle, Norton's Virginia.

No. 6. Norton's Virginia.

No. 7. Norton's Virginia.

No. 8. Norton's Virginia.

No. 9. Catawba.

*See page 328.

Black-rot first appeared on the Labrusca and Vinifera hybrids June 11, and continued to increase until August 9. Downy mildew was first seen on May 27.

Experiments were also made by Mr. Lyman with the view of discovering a remedy for anthracnose. Mr. Lyman writes:

I determined to make an experiment for the prevention of anthracnose, because of the great amount of damage done by it in 1886 and 1887 to my Elviras and Delawares, and also because of its prevalence among other varieties grown in my neighborhood. The preparation used was a saturated solution of sulphate of iron which was applied in the latter part of February, and in the following manner:

Cheap, coarse sponges were wired to the ends of round sticks 15 inches in length; and buckets were used having a spatter strip nailed across the top. The sponge was immersed in the liquid, withdrawn, struck against the spatter strip to save waste, and the vine then swabbed thoroughly from the base to the extremity. Five hundred and fifty vines were treated and fifty left untreated. The entire absence of this fungus where the vines were treated led me to believe that the effects of the application were most satisfactory. The rows of Elviras untreated lost from 20 to 25 per cent. of their fruit, while the untreated Delawares did not bear any grapes worth mentioning, and made a very inferior growth of cane.

Mr. Lyman concludes his report as follows:

The difference in the quantity of fruit and quality of *must* between my treated and untreated Norton's Virginia was so marked at the wine cellar as to call forth the following communication:

CHARLOTTESVILLE, VA.

In receiving grapes from H. L. Lyman, delivered to and bought by the Monticello Wine Company in September and October, 1888, we found a very marked difference in the Norton grapes treated for mildew and rot by the application of copper mixtures from those not so treated. This difference was shown, not only in a much less degree of rot, but more in the *quality*, as indicated by the saccharometer. Those treated were rich in sugar, and consequently of an increased value of one-half a cent per pound or $10 per ton.

OSCAR REIERSON, *Secretary.*

VI.—TREATMENT OF BLACK-ROT IN ARKANSAS WITH THE SIMPLE SOLUTION OF SULPHATE OF COPPER.

By Mr. J. HERTLEIN, *of Spilerville.*

I used the simple solution of sulphate of copper (1 pound of copper to 20 gallons of water) because I could not get the ammonia which is used in the preparation of eau celeste. The first applications were made with a broom on the evenings of April 17 and 19, respectively. Four hundred vines of thirty-five varieties were treated, and one row in the middle of the vineyard was left untreated for comparison. The solution was too strong; it injured the leaves of some varieties badly, especially Norton's, Ives, Missouri Riesling, and Berckman's. Delaware did not suffer any, Concord very little. I made the second application May 2 and 3, and left Norton's and Ives untreated. Most of the vines were in bloom at the time. The third application was made between May 16 and 21, using the same solution as before. For the second and third applications I used 30 gallons of water to 1 pound of the copper; the part of this solution put on in the morning when the dew was on the leaves and after a rain burnt the foliage, while that put on in the evening did not hurt it in the least. The best time for applying the remedies I think is about sundown, or even by moonlight. Mildew appeared after a heavy rain on untreated Peter Wylie and Vergennes vines May 16; it also attacked some untreated Berckman's vines. May 17 I found spotted leaves on untreated Concords; on the 18th I gave the mildewed vines a sprinkling of the solution, which stopped further progress of the disease.

May 26 I found the first traces of black-rot on untreated Peter Wylie, also on Vergennes, and a few days later on Concord and other varieties. The 1st of June I commenced picking off the rotten berries (as I have done for the past three years), and kept on picking every three or four days until July 7; I picked in all about 50 pounds of rotten fruit. The difference between treated and untreated vines could be seen at a glance; while the treated ones were only slightly attacked, the untreated rotted badly. Not all the varieties yielded alike to the remedy, and while I could not see any difference between treated and untreated Berckman's and Vergennes, the difference between treated and untreated Concords was very striking. At the

harvest (August 6) the treated vines yielded over 10 pounds to the vine, and the untreated 3½ pounds. Delaware and Norton's were nearly exempt from rot; Ives, Montefiore, Ulster, Empire State, Perkins, and Champion rotted very little.

My vineyard is on a slope with western exposure; one half is trained to wire after the Kniffen system, the other half to stakes. In the spring before the buds started I washed every alternate row of those on wires with a 50 per cent. copperas solution, and on these I could hardly find a rotten berry in the fall. I have full confidence in the remedies, and will experiment again next season. The main thing is to use the remedies early, before and immediately after flowering. I believe that 1 pint used at such a time will do more good than a gallon used later. Picking and destroying the rotten berries should be continued with the foregoing treatment. All the vineyards of my neighbors, where no remedies were applied, were injured by rot from 25 to 75 per cent., while I hardly lost 1 per cent. of my crop.

VII.—EXPERIMENTS AT MIDDLE BASS, OHIO.

Mr. George M. High, of this place, sent in a very full report of his experiments, and the results obtained in the treatment of brown-rot (*Peronospora viticola*). He used eau celeste, making the applications with a Nixon barrel force pump and Nixon spraying nozzle on June 7, June 18, July 6, July 18, and August 7. Two thousand vines, mostly of the Catawba variety, were treated, while a like number of the same variety were left untreated for comparison.

The loss of fruit on the treated vines was about 1 per cent., while on the untreated vineyard fully one-third of the fruit was destroyed.

VIII.—TREATMENT OF THE GRAPE-VINE POWDERY MILDEW (*Uncinula ampelopsidis*) WITH SULPHURET OF POTASSIUM.

Mr. E. M. Hudson, of Mobile County, Ala., used this solution in the treatment of the foregoing disease, and his report contains so many interesting points that it is here submitted in full.

I was making an effort to find some convenient form of sulphur to apply to my European vines (*Vitis vinifera*), when I was attracted by an observation of M. le Vte. Amaury de Montlauer, in Bulletin No. 2 of the Section of Vegetable Pathology, pages 68 and 70, to the effect that he had successfully applied a 1 per cent. solution of liver of sulphur for mildew (*Peronospora viticola*); and he concluded by saying that vineyards treated in the spring had neither *Oidium* nor *Erineum*. I at once decided to experiment with it on Hamburg, Black Hamburg, Muscat, and other European vines growing in the open air, on which, for several seasons, the grapes have been severely injured, and in 1886 entirely destroyed by the powdery mildew (*Uncinula ampelopsidis*). Accordingly I commenced with a 1 per cent. solution, which scorched the young leaves severely wherever it touched them. Next I made a solution of one-tenth the above strength; this was also too strong but the beneficial effects were so apparent that I made a third application, containing one one-hundredth of 1 per cent. of the potassium. This, while promising far more than the two former mixtures, still admonished me that the solution was even then too powerful. Notwithstanding these disappointments, I succeeded in saving a portion of the crop in fair condition.

This year I commenced, when the young shoots were perhaps 6 to 8 inches long, with a solution of half an ounce (avoirdupois) to one gallon of water. It was applied again when the grapes were beginning to color. The solution happened to be quite powerful enough and produced no injurious effects whatever on the tender leaves and shoots. This treatment was applied to two hundred vines (all marked) with absolute and unexceptional success, giving me a full crop of superb clusters of magnificent berries in every instance. About thirty-four vines, interspersed among those treated as above, and left entirely untreated, had their entire crop destroyed by the mildew.

After the crops were gathered the older leaves on the treated vines were attacked by the *Uncinula*, and before they could be treated a long rainy season of six weeks set in so that the remedies were never applied. At the end, however, the foliage of the treated vines, beyond being browned slightly, appeared to have received no further injury, and the late wood growth was satisfactory.

I used the Vermorel machine in applying the solution and it gave perfect satis-

faction. I had the solution freshly prepared and applied it in the early morning, before 8 o'clock, as recommended by M. de Montlaur.

When you take into consideration the cheapness of liver of sulphur, the ease of its preparation and application, the complete success of the treatment, and the fact that the ripe clusters are not blemished by it as they are by the flowers of sulphur, it seems to me that it must commend itself to all growers of European vines, especially those in California, where the *Uncinula* is the chief fungous disease against which grape-growers have to contend.

In preparing the solution, half an ounce of the liver of sulphur was dissolved in 1 pint of hot water; as soon as dissolved, the cold water (1 gallon less 1 pint) was poured with the hot solution, and the whole immediately strained through a thick osnaburg cloth into a tin can and closely stopped. It was then ready for use. It takes but a few moments to prepare it. From the tin can (10-gallon cans were used) the mixture was poured, as needed, into the reservoir of the Vermorel machine and sprayed thoroughly over the vines, clusters, and leaves above and below, the smaller nozzle being used for the work.

I used at each application on two hundred and fifty vines 4 gallons of water with 2 ounces of liver of sulphur. This was perhaps more than was necessary, but I was determined to have the work done efficiently and thoroughly in order to test the value of the application.

IX.—CONCLUSIONS.

The results furnished by the foregoing reports show conclusively that by the proper application of the copper remedies, especially the Bordeaux mixture, we may subdue or even entirely prevent black-rot. Downy mildew can easily be prevented by any of the remedies mentioned in the foregoing circular, as the experiments last year fully proved. It is true that quite a number of those who made trials this year report that no benefit resulted from the applications, but when we come to carefully inquire into such cases we find that where failures are reported the experiments were either carelessly made or were begun too late in the season to be of value. It seems to us that one of the principal reasons for the non-success heretofore attending the use of these preparations lies in the fact that very few grape-growers have the vaguest idea of what the fungi of black-rot and downy mildew are like. They do not know that these minute enemies are plants like the vine on which they feed; that they grow and produce bodies analogous to seed, and that these minute seed or spores germinate and take root, so to speak, whenever they come in contact with the fruit or leaves, providing there is sufficient moisture present. If these facts, and many others connnected with the life history of the fungi under consideration, were known, the importance of beginning the treatments early and making the applications thorough would be readily understood.

Under the present condition of things it is somewhat difficult to outline, in a definite manner, a practical course of treatment for black-rot. As a first step, however, it would be well to carefully collect in the fall as many of the old leaves and berries as possible, and burn or bury them. Then in the spring after the vineyard has been pruned and put in order by the plow, but before vegetation starts, the vines should be thoroughly sprayed with Bordeaux mixture containing 16 pounds of sulphate of copper and 30 pounds of lime to 22 gallons of water. The object of this spraying is to destroy all the spores of the fungus that may have lodged in the bark. About ten days before the flowers open the foliage and vines should receive a second spraying, this time using a mixture containing 6 pounds of sulphate of copper and 4 pounds of lime to 22 gallons of water. A third application, using the latter mixture, should be made when the flowers are opening, taking care to thoroughly wet all the green parts but not to drench them. Repeat the spraying every two

weeks, until the fruit begins to color, using the same preparation as before.

In regions where both mildew and rot prevail, the treatment as outlined for the latter will effectually prevent the former so that it will not be necessary to make any additional applications. Where the mildew is the only enemy to be considered the eau celeste (formula 1 or 2) should be used for the reason that it is cheaper, more readily prepared and applied, and fully as efficacious in this case as is the Bordeaux mixture.

On the 1st of December, 1888, we visited Colonel Pearson's vineyard and found that he had already begun treating his vines with the view of preventing the recurrence of black-rot in 1889. He had thoroughly cleaned his vineyard and had removed all the old bark and dried berries from the vines. The vines had been drenched with the Bordeaux mixture, and slaked lime had also been scattered between the rows, completely covering the ground in many places. Colonel Pearson informed us that he would plow the vineyard in the spring before vegetation started and again give it a liming, after which he would apply the Bordeaux mixture, repeating the sprayings every three weeks throughout the summer until the fruit began to color.

B.—NECESSITY FOR MORE EXTENDED FIELD WORK.

Among the subjects dealt with in the following pages the rot of the potato, tomato, and cherry, and the leaf-blight, and cracking of the pear cause the heaviest losses to farmers and fruit-growers. Each one is probably the cause of thousands of dollars' loss every year, and they are only representative diseases. The agricultural world has long suffered from these diseases in a profound ignorance of their causes.

Against these insidious foes, which are visible only in their effects, the farmer has heretofore had no weapons of warfare. If his potato vines died prematurely, and the potatoes themselves rotted in the hills or in the cellar, he simply said it was a bad year, resigned himself to his fate, and probably used what few potatoes were left for planting his next year's crop. Since this Section was established a continual effort has been made, by means of correspondence, special bulletins, and annual reports, to bring before the agriculturists of the country the fact that these diseases have definite causes outside of climatic influence, to teach them the nature of these causes, and that the diseases can be prevented. The liberality of the Government in circulating large editions of these reports has done much to bring this knowledge within reach of all, and there is no good reason today why agriculturists should longer suffer in unresisting ignorance of the causes or remedies for fungous diseases. Much work in this line remains to be done. The entire history of the fungi causing these diseases is known only in a comparatively few cases; and how important it is that the entire history of all parasitic fungi should be known may be gained by a study of those already described. But in addition to this there is another field of labor which is absolutely necessary if this knowledge is to be made of practical benefit. Under the "treatment" of nearly every disease we are obliged to say, "No experiments have yet been attempted, and the suggestions made are drawn from a general knowledge of the life history of the fungus and the results in the use of fungicides in vine diseases." In other

words, we leave our readers to experiment for themselves, doing all in our power by way of suggestion.

This is not encouraging to farmers; considerable expense is entailed in order to thoroughly test any of these remedies, and few care to add to the possible loss of their crops the additional expense of chemicals and machines for application, to say nothing of the labor involved at a time when other work is especially pressing. If, on the contrary, we were able to lay down a course of treatment and say *This has been thoroughly tested by competent and practical men,* no farmer would hesitate to use the means suggested.

The need of this has been keenly felt by those in charge of the work, but the funds available have not been sufficient to establish any such series of experiments as was desired. It was thought wisest to concentrate what money and force it could command in this direction upon one point, and consequently all available resources were used for two years in experiments with fungicides for black-rot and other diseases of the grape. The result has justified the means and we are now able to say to the grape-growers of the country that this most dangerous foe to their industry may be conquered by a simple and comparatively inexpensive method. One of the results of this work is the invention of the Eureka sprayer, and the number of orders already received for it attest the fact that fruit-growers are anxious to use remedies that have once been tested. It remains for us to make similar experiments in other diseases, but if two years must be devoted to each one our progress will be painfully slow. The demand for more field work is imperative, the resources of the country can never be fully developed while the agricultural community is at the mercy of every infectious disease that now visits its crops. The losses from this source are incalculable, and it devolves upon this Section to take the initiative steps toward avoiding them. The work is possible and extremely practical, and what is necessary in order to accomplish the desired results is to have the funds at our command that will enable us to employ competent men to go into the field and not only investigate the causes but experiment with remedies for the many diseases that are now devastating nearly every cultivated plant.

C.—MISCELLANEOUS SUBJECTS.

The following subjects are discussed in the accompanying pages of this report:

1. Downy mildew of the potato.
2. Notes on black-rot of the tomato.
3. A tomato disease.
4. Brown-rot of the cherry.
5. Powdery mildew of the cherry.
6. Leaf-blight and cracking of the pear.
7. Leaf-spot of the rose.
8. Plum-pockets.
9. Apple rusts.
10. Septosporium on grape leaves.
11. Leaf-spot disease of the maple.
12. A disease of the sycamore.
13. The leaf-rust of cottonwoods.
14. Report on peach yellows.
15. Additional notes on celery leaf-blight.

The paper on "Downy Mildew of the Potato" was prepared by Prof. F. L. Scribner, while that on "Apple Rusts" is by Dr. B. D. Halstead, who has given special attention to this group of fungi. Of the remaining chapters my assistant, Miss E. A. Southworth, prepared Nos. 6, 7, 10, and 12, and also furnished valuable notes on several others. Chapters 5 and 13 are from the pen of my assistant, Mr. M. B. Waite. The illustrations accompanying these were drawn

under my supervision by Miss Roberta Cowing, Miss E. A. Southworth, and Mr. M. B. Waite.

1.—Downy Mildew of the Potato.*

Phytophthora infestans, DBy.

(Plates I, II, and Map.)

I.—GENERAL REMARKS.

The disease of the potato caused by the parasitic fungus *Phytophthora infestans*, generally known as Potato-rot, probably originated in South America, whence it was brought to this country about the year 1840. Since that time it has been the cause of very serious losses to farmers, and in years favorable to the disease has swept away nearly the entire crop.

The cooler and more moist sections of the country are where the *Phytophthora* attains its greatest vigor and activity, and it is only in the dry regions of the great western plateaux that the potato-grower can hope to wholly escape its ravages.

No variety has yet been discovered that has remained free from the disease under all circumstances, although in some localities some varieties are more resistant than others. Possibly also there are some varieties more susceptible than others, and these should be known in order that their culture may be avoided.

II.—BOTANICAL CHARACTERS.

The fungus attacks the stems and leaves as well as the tubers.

On the leaves (Plate I, Fig. 1) pale-yellowish spots first indicate the presence of the disease; these very soon turn brown, and if the weather be warm and damp, rapidly blacken, indicating the total destruction of the tissues. The yellowing of the tissues progresses slowly, but as soon as the fungus has pushed out its fruiting threads, which appear as a white downy coating on the under surface, the discolorations proceed rapidly.

The stems may be attacked directly or the disease may reach them through the leaves; in either case they become blackened and soon die.

On the tubers (Fig. 2) the parasite attains a considerable growth within the tissues before there is any external manifestation of its presence. After a time depressed spots appear and the skin covering these dies and becomes discolored. Underlying these spots the tissues will be found to be dark-colored for a greater or less depth. This browning of the tissues begins before there is any external sign of disease. The flesh occupying the center of the tuber remains for sometime healthy and normal, but in the end it also decays either with dry or wet rot. If infected tubers are stored the rot will progress in the cellar and healthy tubers may be infected by those already diseased. The losses arising from the rotting of the tubers after they are gathered sometimes amount to as much as may have occurred in the field.

* This article is an abstract from a paper by Prof. F. L. Scribner which will be published as a special bulletin.

The mycelium passes between the cells, never into them (Plate II, Figs. 1, 4) except in rare cases. After it has grown a few days in the tissues of the leaf, it sends out branches destined to bear the conidia or reproductive bodies of the fungus (Fig. 2). The method of formation of the conidia is illustrated in Fig. 3. They are formed at the apex of the conidiophore or its branches, and their apparently lateral position is due to the fact that they are turned to one side by a continuation of the growth of the branch. As soon as the conidia are ripe they will germinate if placed in suitable conditions of warmth and moisture. The changes which they pass through in germination are illustrated by Fig. 5. The conidium breaks up (*a–d*) into a number of motile portions called the zoospores (*e, f*,); these have cilia at first, but finally lose them (*g*), surround themselves with a membrane and germinate (*h, i, k, l*); the germ tube enters the plant and reproduces the disease.

There is no longer any doubt that the tubers may be and usually are infected by the rain washing the conidia down into the soil.

III.—CONDITIONS FAVORING THE DISEASE.

In order to intelligently treat the potato-rot it is necessary to understand the conditions which favor its development. These are (1) humidity—the years of great outbreaks have always been years of excessive humidity; (2) a temperature ranging from 65° to 75° F.—a few degrees above 74° will check the development entirely, and down to 45° the fungus will continue to grow; (3) moisture in the soil—hence a clayey soil or one that will retain moisture is more favorable to rot. It is also generally conceded that stable or barn-yard manure, especially if used fresh, favors the rotting of the tubers.

The conditions which favor the rot after the potatoes are harvested are the same as those which favored it before—moisture and a moderately high temperature.

IV.—TREATMENT.

Treatment for potato-rot must be preventive, and prevention in this case consists, first, in not planting diseased tubers, and second in making the conditions unfavorable for the germination of the spores and development of the mycelium, and finally in protecting the tops by fungicides that will prevent the spores from germinating even under the most favorable climatic conditions.

Potatoes used for seed should be perfectly sound; a single tuber containing the mycelium of the fungus may result in a point of infection that will ruin the entire crop. If there has been any disease in the field where the seed potatoes were grown it is not safe to depend upon observation in judging the character of seed selected, for the *Phytophthora* may be present without developing any visible characters. The better plan would be to always disinfect the tubers designed for seed. Whether this can be done without destroying the vitality of the sets must be determined by further experiments. According to Mr. Jensen, however, it is possible to disinfect potatoes to be used for seed by keeping them in an oven for a few hours at a temperature of from 104° to 110° Fahr.

When possible the planter should always select a light and thoroughly drained soil for his potato crop. It is of course impossible to control the weather conditions that favor the disease, and conse-

quently if these are present the vines must be protected by the application of fungicides. The disease is similar to the downy mildew of the grape, and the preparations used for that will be effective for the potato-rot. Preference is given to the Bordeaux mixture, but eau celeste, sulphatine, and blight powder can also be recommended. The applications should be made when there is no wind, and the plants are wet with dew, and should begin before the blight makes its appearance, say during the latter part of July, and repeated about the middle of August.

If the spores of the fungus reach the tubers by being washed into the soil by rains, potatoes but lightly covered with earth are more likely to be infected than when deeply planted; such is generally reported to be the case, consequently the potatoes should have a second or protective molding at the first appearance of the disease upon the leaves, made in such a manner that the uppermost tubers shall have at least 5 inches of earth over them, the tops being bent at the same time so that they hang over the furrows in a half-erect position.

It should be remembered at the time of digging the crop that the tubers may become infected as they are taken from the ground, by spores from the decaying tops. If the digging be delayed for a week or two after the tops have become thoroughly dead, and performed when the weather is sunny and dry, there is little possibility of infection at this period.

Potatoes should be entirely free from surface moisture when stored, and never should be placed where it is damp or where moisture can collect about them. Dusting the tubers with air-slaked lime (1 bushel of lime to 25 bushels of potatoes) before storing is strongly recommended; it will do much towards preventing the rot. If during the winter the potatoes are found to be rotting they should at once be sorted over and all spotted or unsound ones treated with lime and stored where the temperature is low and the atmosphere dry.

2.—Notes on Black-rot of the Tomato.

(Plates III, IV.)

I.—GENERAL OBSERVATIONS.

Horticulturists and farmers have suffered considerably of late years from a disease of the tomato which is known everywhere as "rot." The term as generally used includes a number of diseases which are quite distinct from each other. It is not, however, the purpose of this paper to enter into a discussion of the various kinds of rot; we shall rather attempt to bring together some of the facts concerning one very important form which has come more particularly under our observation during the past year, and in order to distinguish it from similar diseases it will be here designated as "black-rot."

Specimens of this have been received from nearly all parts of the United States where the tomato is grown, and farmers complain bitterly of its ravages.

Although several mycologists have devoted considerable time and study to the malady, the results so far obtained as to the cause of it are far from conclusive or satisfactory. Doubtless this is owing to the fact that the rot is not always the result of a single agent, but is more often due to several combined causes.

II.—EXTERNAL CHARACTERS.

The disease as a rule makes its appearance at the apex or flower end of the fruit when the latter is from one-half to two-thirds grown. At first a small blackish spot is seen either around the remains of the style or on one side of it; this rapidly increases in size, but retains a more or less circular outline (Plate III, Fig. 1). As the disease progresses the tissues collapse quite regularly on all sides, and the berry becomes much flattened (Fig. 2). There is usually a slightly raised, narrow border surrounding the diseased parts, while just outside this the cuticle retains its normal healthy color, but appears slightly wrinkled, owing to the collapsed condition of the tissues beneath. Sections through a rotten tomato at this stage show that the black discolorations extend deeply into the tissues, the depth depending somewhat upon the size of the spot. As the malady progresses the diseased parts become hard and leathery, the suface assumes a greenish-black, velvety appearance, and finally the entire fruit becomes dried and shriveled.

III.—LOSSES, CONDITIONS KNOWN OR SUPPOSED TO FAVOR THE DISEASE, ETC.

In parts of Indiana, Michigan, Wisconsin, and Mississippi the disease is very destructive, in many cases causing almost a total loss of the crop. The following extracts from correspondence will give some idea of its ravages.

A correspondent writes from Montgomery County, Ind., as follows:

> The black-rot of the tomato has prevailed to an alarming extent in this locality for the last three or four years, affecting, however, only the first-formed fruit, but eventually destroying fully one-third of the crop.

Professor Taft, of the Agricultural College of Michigan, says:

> The only severe cases of rot which troubled us this summer were on a dry sandy knoll, and occurred during the drought of August. The vines were not trellised, and the fruits which rested on the ground were affected on the under side. We had only a few varieties on this place, and the "Mikado" and "Acme," with other pink kinds, seemed to be most injured. Upon our experimental plot, which contained one hundred and fifty varieties, only an occasional fruit was diseased.

Professor Tracy says that at Crystal Springs, Miss., he found the disease very severe on April 24, 1888, fully one-fourth to one-half the fruits being affected in a number of fields examined. On May 1 nearly one-half of the fruit in some fields was affected, and on June 1 the disease had nearly disappeared. In July he was unable to find specimens for study.

> In Wisconsin (writes Professor Tracy) it appears in July or August and continues until frost. In one garden there it has been noticed as affecting the crop very seriously for three years, but this year, with no noticeable peculiarity of the season, it was not to be found on plants grown on the same ground from seeds of plants affected last year.

He concludes by saying that he tried sulphatine, David's powder, etc., this year, but as the disease disappeared from untreated plants soon after, the results were negative.

As stated above the fruit is most subject to attack when two-thirds grown, and, from the reports of correspondents, it appears that the disease is especially virulent during the latter part of July and the whole of August. It is also generally believed that it is most severe in seasons when wet weather prevails at the time the fruit begins forming.

In response to a number of inquiries, sent out by the Section to determine, if possible, what effect the character of the soil, pruning, trellising, manuring, etc., had upon the disease, a number of replies were received, but the opinions expressed in these are so contradictory that no practical conclusions can be drawn from them. According to Professor Maynard of the Massachusetts Agricultural College, the rot this year was more severe upon soil where there was only a limited supply of manure applied. Professor Taft expresses practically the same opinion as that of Professor Maynard.

Professor Bailey* says that an abundant use of stable manure appears to augment the disease; and this seems to be the general belief of most of our correspondents.

From the observations of Professor Goff of the New York Agricultural Experiment Station, the rot appears to flourish most on the more vigorous plants. He says that a vigorous plant of "Cook's Favorite" tomato, grown from mature seed, had 18 per cent. of its fruit affected with black-rot; while a feeble one, grown from immature seed, had but 5 per cent. of its fruit destroyed.

Some varieties appear to be more subject to the rot than others. It appears from all the evidence at hand that the "Acme" and "Mikado" are especially subject to the disease, while the "Perfection," "Paragon," and "Trophy" are not so liable to its attacks.†

IV.—CONCLUSIONS AS TO THE CAUSE OF BLACK-ROT.

In all the specimens which have come under our observation during the past year, we have invariably found two species of fungi; finding these always associated with the rot, the questions natually arise as to what connection they have with the disease, and whether they are really the cause of it or are to be considered as a simple incident of the malady. In order to discover if possible the relationship existing between the two fungi and the rot, a study of the former was begun, and the results of these observations are as follows:

A section through one of the velvety, greenish spots shows that the color and peculiar appearance are due to the presence of a vast number of short, dark, olive-brown threads (Plate III, Figs. 3, 7), upon the free ends of which are borne obclavate, many celled bodies (Fig. 5); these readily separate from the supporting stalks, and are found thickly scattered over the surface of the diseased parts. Associated with this fungus is another which consists of dense tufts of nearly colorless, club shaped stalks, occasionally bearing crescent-shaped, slender bodies, much smaller than those first described (Plate IV, Figs. 1, 2, 3). The dark-colored fungus is *Macrosporium tomato*, Cook,‡ while the colorless species is a *Fusarium*, which agrees with specimens and descriptions of *F. solani*, Mart.,§ a species commonly found

* "The worst cases of rot this year (1887) occurred upon plants grown on a freshly turned sod which had been previously dressed with manure."

† According to Professor Bailey, the angular, pear-shaped, and cherry varieties, and those immediately derived from them, have been almost exempt from attack.

‡ *Macrosporium tomato*, Cook. Grevillia XXII, p. 32. "Spots orbicular; hyphæ short, large, flexose, septate; conidia clavate, slightly attenuated above, short stalked below, consisting of brownish spheroidal cells. On ripe tomatoes, S. Carolina (Ravenel)." Our specimens do not agree with the foregoing description in all cases, but a comparison of the material at hand with authentic specimens of *M. tomato* shows that the two forms are identical.

§ The so-called *Fusarium* which occurs abundantly on rotting potatoes has been pretty thoroughly studied by the German mycologists Reinke and Berthold. Their investigations resulted in the discovery of the mature or ascoporous form on old and

on rotting potatoes. The *Macrosporium* is usually the more abundant of the two, and while it is, as a rule, found upon spots of all sizes, the *Fusarium* rarely appears until decay is pretty well advanced.

V.—MICROSCOPIC CHARACTERS OF THE MACROSPORIUM.

The *Macrosporium* consists of a mycelium or vegetative system, spores or reproductive bodies, and spore-bearing hyphæ.

Mycelium.—The vegetative part of the fungus is made up of rather large, septate, thick walled, more or less contorted tubes which are at first nearly colorless, but eventually become tinted with brown; these are found in all of the decaying parts and can be readily traced into the sound tissues (Plate III Fig. 7 *a*). They are especially abundant near the surface, forming here pretty evenly distributed, more or less dark colored mats.

Spores.—The spores are borne upon the ends of short or long, septate, olive-brown, rather thickish hyphæ (Plate III, Figs. 3, 4, 7), which spring from the dark-colored mycelium. They are made up of from three to fifteen spherical cells, and vary greatly in size and shape, being when full grown broadly obclavate, and from 20 to 25 μ in diameter by 100 to 140 μ in length (Fig. 5). Their color at first is olive-brown, later they become darker, frequently almost black. They germinate readily in moist air or water by sending out one or more slender tubes from each cell (Fig. 6). At first the germ tubes are colorless and without septa; later they become tinted with brown and divided by frequent cross-walls.*

VI.—MICROSCOPIC CHARACTERS OF THE FUSARIUM.

This fungus, so far as we have been able to trace its development upon the tomato, consists of a vegetative part, or mycelium, and spores or reproductive bodies of two kinds, namely, macroconidia and microconidia.†

Mycelium.—The mycelium or plant body of the fungus consists of delicate, colorless, septate threads, which penetrate the tissues of the fruit in all directions, appropriating the juices for its own sustenance. It is much more abundant than the mycelium of the *Macrosporium*, and differs from the latter in being more slender, lighter colored, thinner walled, and not usually contorted; another difference is that while the mycelium of the latter is confined for the most part to the surface, that of the *Fusarium* is frequently found in the center of the fruit, and shows a much greater tendency to penetrate

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badly-decayed potatoes. According to these authors this form consists of pear-shaped perithecia, within which the asci with their contained sporidia are borne. The swollen part of the perithecium is of a bright-purple color while the neck is bright orange. This form has been referred by Reinke and Berthold to the genus *Hypomyces*, and by careful experiments they have proved beyond question that it is the mature stage of *Fusarium solani*, Mart. This being the case, the generic name *Fusarium* has been dropped, and the name *Hypomyces* is now made to include both forms. So far as the life history of the fungus occurring upon tomatoes has been traced it agrees essentially with the *Fusarium* form found upon the potato. Moreover, the spores of the tomato fungus when sown upon the potato grow readily We are not aware, however, that the ascosporous form has ever been found in this country either upon the potato or tomato, and until this is accomplished the relationship existing between these forms can not be definitely proved.

*Both the hyphæ and spores are exceedingly variable; at times the former are long and nodulose and bear spores which can not be distinguished from those of the genus *Cladosporium*.

† *Macroconidia*, large conidia compared with others (*Microconidia*) produced by the same species.

the sound tissues. Thin sections, taken near the edge of a rotten spot, often show the ends of the mycelium penetrating the tissues where the contiguous cells are apparently healthy (Plate IV, Fig. 8).

Macroconidia.—These are the most important reproductive bodies, economically considered, as they are produced in prodigious numbers and doubtless serve for the rapid propagation of the fungus. They develop in several ways. The mycelium may rupture the epidermis in places, sending out tufts of club-shaped conidiophores, which form spores by constriction. The immature conidia appear to be merely the enlarged ends of mycelium threads (Figs. 1, 2). In another form the tufts are longer and denser, the base and center appearing like a colorless stroma, the conidiophores are branched and septate (Fig. 3), and each ultimate branch bears a macroconidium. On old and badly diseased tomatoes it is common for the mycelium to run over the surface, sending out numerous upright branches, each of which bears a spore at the end (Fig. 2). When full grown they are colorless, crescent-shaped, nearly cylindrical, and vary in size from 5 to 7μ in diameter by 10 to 50μ in length (Fig. 4). They are usually divided by from two to six transverse partitions or septa, and are filled with a fine granular fluid. Each division is provided with one or more vacuoles, which increase in size when the conidium is exposed to moisture. When sown in water they will, in a few hours, send out germ tubes (Fig. 5 *a*), and these, by continual branching (Fig. 5 *b*), soon develop into a mycelium. Before germination takes place the spores often become constricted at the partitions.

Microconidia.—The microconidia (Fig. 6) are usually found in great abundance in old and badly decayed tomatoes. As a rule they are borne upon short branches of the mycelium, and are spherical and smooth when young (Fig. 6 *a*), but later become roughened with small wart like projections (Fig. 6 *b*). At first their color is a light yellow; later this becomes brown. They vary in size from 8 to 16μ in diameter, their average size being about 12μ. They are filled with a granular fluid, and are provided with several large oil drops, which become more pronounced as the conidia approach maturity, but are not so well made out in the full green warty forms. These microconidia do not germinate readily under artificial conditions, often remaining for a month in water without undergoing noticeable change. In germinating (Fig. 7) they send out one or more slender tubes, which do not materially differ from those of the macroconidia.

Frequently macroconidia are developed directly upon these germ-tubes, and *vice versa* microconidia are occasionally developed upon germ-tubes from the macroconidia (Fig. 5 *c*).

VII.—LIFE HISTORY.

As yet it is not definitely known how these fungi pass the winter. At this writing (December 1) both the *Macrosporium* and *Fusarium* spores can be found upon the dried and shriveled fruit which long ago fell from the vines. An abundance of the spores of the former fungus also occurs upon the old leaves and stems.

Upon a number of specimens of half rotten tomatoes collected in the Department grounds the latter part of September, a fungus was found which seems to be connected with the *Macrosporium*. As seen under the microscope, this form consists of rather large round or ovoid, dark colored bodies, which, as they increase in size, break through the tissues and appear on the surface.

In sections it is seen that they are filled with small round or oval

spores which escape through an opening in the top. Around this opening, and upon the outside wall, numerous tufts of hyphæ and spores of a *Macrosporium*, which do not differ from *M. tomato*, are borne. Considered independently the ovoid bodies or conceptacles, as they may be called, would be referred to the genus *Phyllosticta*, but there seems little reason to doubt that in this case they are really a part of the *Macrosporium*.

It is very probable that this fungus passes through several stages before finally reaching maturity, and that one if not more of its forms will be found during the winter in the old tomatoes destroyed the previous summer by the *Macrosporium*.

In regard to the *Fusarium* we have seen that at least two kinds of spores are produced. From the fact that the microconidia germinate with difficulty it is very probable that they are designed to preserve the life of the fungus during a greater part of the winter or under conditions which would prove fatal to the macroconidia.

During the month of September, 1888, when there was an abundance of fresh material at hand, a series of experiments was made with the view of discovering, if possible, whether the rot could be induced by sowing the spores of the *Macrosporium* and *Fusarium* on healthy tomatoes. In the first place, germinating conidia of the *Fusarium* were repeatedly sown on the uninjured surface of both green and ripe tomatoes, but in no instance was there any appreciable effect produced. Conidia were also inserted under the skin of green, half ripe, and ripe fruit, and while no change took place in the case of the green and half ripe specimens, the ripe fruit rotted in a few hours. A microscopic examination of the tissues of the latter showed the mycelium of the *Fusarium* running over, under, and through the cells in all directions and producing its characteristic crescent shaped spores in great numbers.

It has probably often been observed that tomatoes crack when exposed to excessive moisture; these cracks or fissures occur either at the point of attachment or at the style end of the fruit, but more often at the latter. They are often so small as to be nearly invisible to the naked eye, while at other times they are quite large and prominent. By way of experiment spores of the *Fusarium* were sown upon both green and ripe fruit, showing these fissures, and as a result the ripe specimens rotted completely in a few days but the green fruit was not affected.

Similar experiments to those described above were also made with the *Macrosporium* spores. In this case, however, infection of both green and ripe fruit was readily effected by inserting the spores under the skin or sowing them in the fissures to which we have already referred. When sown on the uninjured fruit no effect whatever was produced.

Another series of experiments was undertaken with the view of discovering, if possible, whether the *Fusarium* spores would grow when sown on green fruit affected with the *Macrosporium*. It was shown by these trials that the spores of the *Fusarium*, when sown on fruit already partly destroyed by the *Macrosporium*, grew readily and greatly accelerated the disorganization of the tissues.

Summing up the results obtained from the foregoing experiments it appears (1) that neither the *Fusarium* nor *Macrosporium* has the power of penetrating the sound cuticle or skin of the tomato; (2) that the *Macrosporium* spores, when brought in contact with the exposed tissue of either green or ripe fruit, produce the rot in a very short

time; (3) that the *Fusarium* will grow only in fully ripe tissues or tissues which have been partly disorganized through other agents.

VIII.—TREATMENT.

While our present knowledge of the disease is not sufficient to warrant us in indicating any definite line of treatment, it is probable that the malady may be prevented in a measure by observing the following precautions. Beginning in the fall it would be well to burn all the old vines, as we have already seen that the spores of one of the fungi at least occur abundantly on the leaves and branches.

All of the old and partly decayed fruit should also be burned or buried, thus securing the destruction of the fungus in whatever form it may live over winter. It would also be well to avoid the excessive use of fresh stable manure, as our observations lead us to believe that the fruit on plants thus fertilized is much more likely to crack, thereby opening a way for the fungus.

It is very probable that the fruit, as a rule, is first infected by the spores of the *Macrosporium*, which send their slender germ tubes through the minute fissures usually found at the apex or blossom end of the berry. After the *Macrosporium* has opened the way the *Fusarium* comes in and assists in the disorganization of the tissues. When practicable, therefore, it would be well to destroy the diseased fruits as soon as they appear, thereby destroying many spores which otherwise might possibly infect adjacent fruit.

So far as we are aware there have been no experiments undertaken to determine the value of fungicides in combating this disease, but by way of trial a solution made by dissolving one-half an ounce of sulphuret of potassium to the gallon of water might be used. This preparation should be applied by means of a spraying apparatus, taking care to thoroughly wet all parts of the fruit. The first application should be made when the fruit is about half grown, repeating the operation at intervals of ten days until the fruit begins to color.

The following report embodies the results of observations made on this disease at New Ross, Ind., by Dr. Homer S. Bowers, an agent of the Section:

IX.—REPORT OF DR. H. S. BOWERS.

The tomato in this section has been remarkably exempt from disease until within the last few years. Plants which escaped the dangers from late spring or early summer frosts, occasional ravages of the cut-worm, and later attacks of the tomato-worm, were considered out of danger. But this condition of things is now changed, for within the last few years another enemy, which seriously threatens the profitable cultivation of this valuable fruit, has made its appearance in the form of a disease commonly known as tomato-rot.

This disease usually appears at the junction of the style with the ovary, and is first seen as a brownish black, scale like spot, dry and somewhat leathery in appearance, and sunken to some extent below the surface. In a few days it spreads over one-fourth, or perhaps one-half, the surface of the fruit, sometimes extending uniformly around the style scar, but at other times developing almost wholly on one side, leveling and depressing the surface as it extends. The berry at the same time becomes wilted and presents a blistered or scorched appearance, but at all stages there is a distinct contrast in color between the sound and unsound tissues. The diseased portions also become slightly wrinkled, and although they were before smooth and glabrous, they soon become glaucous from the growth of a powdery fungus, which is always found in connection with the malady. This mold does not occupy the whole of the diseased portions, but mottles the surface to a greater or less extent, presenting various blotches and markings, which vary in color from brown to a dirty brownish black.

It attacks the fruit in all periods of development, but preferably when from one-third to one-half grown, and when it has once made its appearance it progresses rapidly, especially in those fruits attacked early in the season; in a few days the vitality of the berry is destroyed, its growth ceases, and at the same time its color changes to that of the ripening fruit.

However long or short a time the disease may continue during any one growing season, it in nearly every case begins on the first fruiting stems of the plant, destroying all the fruit that forms on the first one or two clusters, afterwards attacking only a single berry here and there.

Little difference has been noted in the susceptibility of the different varieties, whether red or purple, smooth or corrugated, and though some slight exemption from the rot is claimed for the yellow kinds, further proof is needed to clearly establish it.

The annual loss in this vicinity for the last five years has been about 33 per cent. of the product of all plants attacked, or 25 per cent. of the whole crop. So far as we have been able to discover the disease seems to be pretty generally disseminated through this part of Indiana, although there are some localities of greater or less extent that are exempt.

On the first appearance of this disease, some five years ago, the gardener or farmer whose plants were mostly allowed to take their own course of growth attributed the rot to his own carelessness in neglecting to give his plants support and to keep them from contact with the damp soil. A year or two of experience has eradicated this notion, for some careful cultivators who always trained their plants and pruned away all superabundant foliage were almost as heavy losers by the disease as those who gave no special care to their vines.

The rot seems to be most destructive where the soil has been fertilized with unrotted stable manure. But one exception to this was noted, in a garden where the soil, a close clay, had not been manured for several years except in one spot, where the slops from the house had been thrown. Here the loss was about 20 per cent., and the disease lasted until well along in September. Tomatoes grown in old hotbeds are much more subject to the disease than those grown in ordinary garden soil; in fact, all the evidence which we have been able to gather leads us to believe that the use of fresh manure is almost certain to be followed by a severe attack of rot. At the time the disease first appeared in our garden, some five years ago, we were accustomed to manuring heavily every spring with stable manure only partially rotted, always pruning and tying the plants to branched stakes. The disease appeared when the first fruit formed, and continued until probably the first two fruiting clusters were cleared, then it ceased. This year, thinking the soil rich enough, we omitted to manure the ground, and as a result we had but one plant that produced diseased fruit, and this in a garden where the disease has held sway for at least four years. As to pruning or not pruning, we can not learn that it affects the case much either way; we believe, however, that pruning and tying to stakes or trellising is to be preferred in all cases to leaving the vines on the ground or even allowing them to run on brush or frames without pruning.

In this locality there has been little opportunity for determining the influence of atmospheric conditions upon the rot. The seasons have been mostly dry since its advent here, last summer (1887) exceptionally so, with a corresponding high range of temperature. What a really wet season might do for it we have had no means of estimating.

In the following notes on treatment what little has been learned has been acquired in a fortuitous way from observations of the varying conditions of environment and methods of culture, afforded by soil, location, and the various horticultural notions of different persons. Throughout this State no line of treatment has been undertaken, and the disease has been generally considered by the people as a mysterious dispensation of Providence and accepted with a certain amount of resigned inactivity born of a profound ignorance of the whole subject.

Our observations seem to indicate that soil containing fertilizing material in great excess of the demands of plant growth, and especially if it is in a state of active decomposition, greatly aggravates the rot. In view of this fact it is probable that by applying manure to the ground in the fall, using well rotted fertilizers and turning them under, the disease may in a measure be prevented. The application of ashes will not prevent it; and the throwing of slops on the ground, particularly if the soil is heavy, and not often stirred, seems to invite the attacks of the malady. An open, porous soil, rich in organic plant food that has already undergone decomposition, if kept stirred deep enough to thoroughly aerate it, offers but a poor abiding place for the fungus, and its attacks if made will be of short duration.

Respectfully,

H. S. BOWERS.

Hon. N. J. COLMAN.

3.—A Disease of the Tomato.

(Plate IV.)

I.—GENERAL OBSERVATIONS.

In December last Mr. Marcius Wilson, of Vineland, N. J., sent to the Department for examination some diseased tomato leaves, and in a letter accompanying them he says:

I send you a small package of tomato leaves from our greenhouses. We have about 12,000 feet of glass, that have been devoted chiefly to winter tomatoes for several years past. The plants have already yielded, this month, several hundred pounds of beautiful ripe tomatoes, and more are coming on, but a peculiar mildew, which has troubled us some before this, now threatens to destroy the vines entirely. The lower leaves of the vines have always been more or less affected with apparently the same kind of mildew that is seen on tomatoes out of doors, but generally they outgrow it. The mildew under consideration attacks the leaves of the terminal shoots. It appears in small dark-colored spots, spreads rapidly, and affects the vigor of the plants much more than the other kind.

We have tried sulphur on the hot-water pipes, and have dusted it over the leaves, but without any apparent benefit. For the purpose principally of absorbing moisture and drying the atmosphere, we have also dusted lime very freely over the plants, but nothing as yet has served to check the spread of the mildew. We are now very anxious to learn more about the character and cause of the species of mildew I send you, and especially to find a remedy for it.

The larger part of the vines in the houses are more or less affected by the fungus seen on the large leaf from the lower part of the vines. This disease of the lower leaves has affected our plants for several years, but the peculiar dark spots on the terminals first made their appearance about three winters ago. Occasionally, especially late in the fall or early winter, a vine affected in its terminal shoots would show a black streak down the stalk for a foot or more, and large numbers of such plants would die in a short time. This season but few of the vines have died, but their growth has been seemingly checked. The plants have been kept very dry for several weeks past, and this has perhaps somewhat checked the development of the fungus, but now we do not see that abundant watering makes much change in the plants affected. A few weeks ago, during a light fall of snow, which lasted about twenty-four hours, the fungus spread rapidly, although the houses were kept about as warm as usual.

Replying to Mr. Wilson's queries, it was stated that the tomato leaves submitted for examination showed that the vines were suffering from the attacks of a fungus, named *Cladosporium fulvum* * by Prof. M. C. Cook in 1883, from specimens sent him from North Carolina.

From an account of this fungus written by Mr. C. B. Plowright, and published in the *Gardeners' Chronicle*, October 29, 1887, it appears that in England the tomato vines have suffered from its attacks to a greater degree, even, than in this country. The fruit, as well as the foliage, is subject to the ravages of the parasite, and to illustrate how rapidly it may spread, Mr. Plowright makes the following quotation from a letter from one of his correspondents:

My plants have been very healthy all the year. On the 16th I noticed a few spots on the leaves here and there; on the following day (17th) I took a walk through the houses. On examining the foliage the spots were seen to be spreading very rapidly. By Monday morning, the 19th, to my surprise, every plant in the house was affected, but not many of the fruit showed it at this time. To-day (26th), however, I found several like the specimens sent herewith. I have about six hundred young plants in cucumber-houses for the winter. On looking at these closely this afternoon, I see that the disease is making its appearance in every house.

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* *Cladosporium fulvum*, Cke. Grev. 1883, p. 32. Effusum fulvum, lanosum; hyphis erectis, flexuosis, septatis, nodulosis, parce ramosis, fulvis; conidiis ellipticis, uniseptatis, vix constrictis, pallide fulvis, hyalinus, 10–20 by 4.5μ. In foliis lycopersici in Carolina Americæ Borealis, Ravenel, No. 599.

The tomato leaves submitted by Mr. Wilson very clearly show the appearance and effect of the disease on the foliage. Brownish, felted spots of irregular size and outline appear on the under surface of the leaves as a first manifestation of the disease; these gradually spread, at the same time corresponding points on the upper side assume a yellowish color. As the disease progresses the affected parts become dark-brown or nearly black, and as a final result of the action of the fungus the leaves shrivel and dry up.

II.—BOTANICAL CHARACTERS OF THE FUNGUS.

Under the microscope it is seen that the vegetative portion or mycelium of the fungus consists of delicate, colorless, septate threads; these are often found penetrating the tissues in all directions, and occasionally overrun the surface. The reproductive bodies or spores are borne upon erect branches which spring from the mycelium in dense tufts (Plate IV, Fig. 9). They vary considerably in size and shape, being oval or elliptical when full grown, 10 to 18 μ in length by 4 to 7 μ in diameter (Fig. 10). They are usually divided near the middle by a transverse septum or wall. They germinate readily in water or moist air by sending out one or more slender germ-tubes, which rapidly increase in length, soon developing into a mycelium like that from which they were derived (Fig. 10 *d*).

The hyphæ are, as a general thing, very irregular in length and diameter, and are often provided with tooth-like or swollen projections on the sides upon which a chain of from three to five spores are borne (Fig. 11 *a*).

According to Dr. Halsted* this fungus occurs abundantly upon the leaves of tomatoes grown in open air in the vicinity of Ames, Iowa. In 1883 some experiments were made at the latter place to determine, if possible, whether the spores from the leaves would, when sown upon the fruit, produce rot. Portions of the affected leaves were attached to healthy, green tomatoes; spores were removed with a knife and placed in a cavity of the stem, or on the blossom end, according to circumstances. Other tomatoes had a cross made in them with a knife just through the skin, while others with the skin cut in the same manner had the spores of the *Cladosporium* placed on the exposed tissues of the tomato.

In two instances the rot quickly followed the application of the spores to the green tomatoes while on the vines. In one case the decay was pronounced, the sowing having been made in a depression at the stem attachment, which was uppermost. The rot that appeared at this point soon destroyed the berry and spread to others in contact with it. The green, partly grown fruit that was removed and left without any treatment remained in a healthy condition for a long time. The tomatoes that were cut and not sown with any spores kept in good form, and the exposed surfaces quickly seared over. The fruit with similar incisions and having spores from the leaves rubbed upon it, soon began to rot at the cut surface and was shortly decayed throughout. In like manner the tomatoes having two crosses began to decay at the incisions sown with the fungus, while those free from the spores dried on the surface and became healed over.

With our present limited knowledge of the habits of this fungus it is impossible to indicate any definite line of treatment. It is prob-

* Proceedings of the Society for the Promotion of Agricultural Science, 1883, p. 42.

able, however, that we may succeed in saving tomato plants grown under glass by spraying the foliage with a solution of sulphuret of potassium, one-half an ounce of potassium to the gallon of water.

To be effective this preparation should be applied frequently—say once every ten days—beginning when the plants are small and before they become crowded. In no case should the spraying be deferred until the fungus has made its appearance, as it will then be too late to produce any beneficial results. The fungus is more likely to attack plants under glass which have been subjected to sudden changes of temperature such as may be caused in winter by the fires becoming low or too much ventilation during cold, and especially windy weather. Care should be taken, therefore, to keep the temperature as nearly even as possible, and as tomatoes require considerable heat this is quite a difficult task, especially in the North.

4.—Brown-rot of the Cherry.

Monilia fructigena, Pers.

(Plates V, VI.)

I.—GENERAL OBSERVATIONS.

Of all the diseases that affect the cultivated cherry the one here designated as Brown-rot is without doubt the most wide-spread and destructive. This malady occurs throughout the entire country, and the losses resulting from its attacks are frequently very great. From the information which we have been able to gather from various sources we infer that while nearly all fruit-growers are familiar with the effects of this disease there are few who know its cause.

Mycologists, however, have known for a long time that it is due to the presence of a minute parasitic fungus which, owing to its wide distribution, together with the fact that it occurs upon quite a number of pomaceous and other fruits, has received many names.*

The first account of the fungus worthy of note was published in 1879 by Von Thümen in his *Fungi Pomicoli*.† In 1885 it was again made the subject of a paper by W. G. Smith in the *Gardeners' Chronicle*,‡ and the same year Prof. J. C. Arthur published a detailed description of its habits in the fourth report of the New York Agricultural Experiment Station.§ It is held by some mycologists that it occurs only upon fruits which have previously been injured by insects or other agents, but careful investigations have shown the fallacy of this, for it is known that the parasite attacks not only sound and immature fruit, but often destroys leaves, flowers, and even young branches.‖

**Agrosporium fructigenum*, Pers., *Oospora candida*, Wallr., *Oidium Wallrothii*, Thüm., *Oidium fructigenum*, E. & K., etc.

† Page 22.

‡ Page 52.

§ Page 280.

‖ Von Thümen (Fungi Pomicoli, p. 23) asserts that the fungus really possesses antiseptic qualities. According to his statement pears thoroughly covered with the fungus will remain for weeks upon moist ground without decaying, whereas those free from the parasite show signs of decomposition in the course of a few days when exposed to similar conditions. Hallier (Wiener Obst- und Gartenztg., 1876, p. 117) explains this by assuming that the *Monilia* prevents the access of yeast fungi and other agents of rapid decay.

II.—EXTERNAL CHARACTERS.

On the flowers.—The fungus makes its appearance on the flowers soon after or about the time the petals fall. At first a slight discoloration appears at a given point; this rapidly increases in size until at length the entire flower assumes a brownish hue.

After killing the flower the fungus frequently attacks the pedicels where it produces similar discolorations to those described above. The dead flowers usually remain on the tree for three or four weeks, then if the weather is wet they begin falling, and as they consist at this time of a soft mass of rotten tissue they stick to any part of the tree with which they come in contact. Many fall upon the leaves and young fruit and become so firmly attached that no ordinary rain or wind will remove them (Plate V, Fig. 3 *c c*).

Careful experiments have shown that the rotting flowers are highly infectious, and that wherever they touch the leaves or fruit decay sets in.

On the leaves.—Here the presence of the fungus is first made manifest by a slight discoloration of the tissue around the point of infection; this gradually enlarges and at the same time the normal healthy green color changes to reddish-brown. The diseased spots are visible on both sides of the leaf, being, however, usually more distinct upon the upper surface. They have no regular shape and their outline is not, as a rule, sharply defined (Plate V, Figs. 1, 2). During wet weather the spots on the upper surface are frequently studded with little tufts of the fungus; these usually have a mealy or pulverulent appearance, and are easily washed off by rain or removed by the wind.

On the fruit.—As in the case of the leaves, the fruit is often infected by means of the diseased flowers. At first there appears a brownish circular spot on one side of the cherry; this rapidly enlarges and soon the entire fruit becomes brown, shrunken, and soft. Ultimately the stalk which supports the fruit is attacked, and finally the whole, the stalk and the fruit, either falls to the ground and dries up, or remains hanging on the tree throughout the summer, or, as frequently happens, until the following spring (Fig. 3 *a*). The fruit is often covered with tufts of the fungus similar to those occurring upon the leaves, and while in this condition they are highly infectious. causing all the fruit with which they come in contact to rot.

III.—BOTANICAL CHARACTERS.

The fungus consists of a vegetative portion or mycelium and spores or reproductive bodies.

Mycelium.—The mycelium traverses the tissues of the fruit, leaves, or flowers, as the case may be, in all directions, and under its action the external effects described above are produced. In addition to the cherry the mycelium was examined in the peach and apple. In the peach it is thin-walled, septate, of varying diameter, and its contents are filled with vacuoles (Plate VI, Fig. 4). This was found mainly between the cells, but in some cases it seemed to have penetrated them. The cells, however, were everywhere permeated with a very fine mycelium (Fig. 3), and in one or two cases this seemed to be continuous with the coarser kind.

In the fresh apple this coarser, thin-walled mycelium was also found, but in a dried specimen the appearance was totally different.

In the latter case the mycelium between the cells was very thick-walled, so that the contents appeared like a fine thread running through the center (Fig. 2) and not occupying more than one-sixth the diameter of the thread. The walls had a shining, white appearance, making the mycelium very prominent wherever it occurred. This was not seen in the cells, but both inside and outside there was an abundance of the fine mycelium already described, which has about the diameter of the contents of the large filaments, and walls that are scarcely visible.

Where the epidermis is separated from the tissue by the pressure of the stroma at the base of the fruiting tufts there is often a triangular empty space entirely around the stroma, and this space contains great numbers of these fine threads. The union of these with the coarser threads is shown by the fact that the latter may be seen to run out into the fine threads (Fig. 2 *b*). The transition is not gradual; the walls suddenly disappear and only the contents seem to be continued, but careful focussing will show that the walls are really present but so thin as not to be seen readily. In two cases what seemed to be the passage of the mycelium into the cell was observed. The appearance is shown in Fig. 2 *a*. Directly opposite the point where the coarse mycelium comes in contact with the cell wall is a small round hole just large enough for one of the fine threads to pass through.

The union of either the fine or coarse threads with the stroma was not followed out, but both are very numerous all around it. The stroma is composed at the base of thin-walled pseudo-parenchyma that merges into parallel threads having the same structure as the thin-walled mycelium of the fresh peach and apple. These hyphæ push up through the epidermis (Fig. 1), branch and diverge, and finally each bears a chain of spores; the chain of spores may also branch. The spores multiply from the end of the chain so that the terminal one is the youngest.

Spores.—The spores are one-celled, colorless, and filled with a granular protoplasm (Figs. 5, 7). Their shape differs a little on different hosts, but they may generally be described as oval. They germinate readily in moist air or water, producing a germ filament which is filled with a granular substance like the spores and contains occasional septa (Figs. 5, 6).

The germ-tubes from isolated spores often grow to a considerable length before branches are formed; this ultimately takes place, however, and by continual growth the tubes finally develop into a mycelium which does not differ from that found in the diseased tissues. When several spores in close proximity germinate, the tubes therefrom often coalesce with one another in the following manner: the tips of lateral branches sent out from the main tubes come in contact with each other, and where this occurs the walls of each disappear and the now united branches consist of a continuous tube holding the main filaments together (Fig. 5). Frequently a lateral branch comes in contact with the main tube from another spore, and in such cases the walls of each—the main tube and the branch—disappear and a complete union is thus effected.

The spores are capable of retaining their vitality for a long time; specimens collected in July, 1886, furnished spores which germinated in May, 1888.

Spores from cherries which had hung on the tree for a year germinated readily in moist air, and when sown upon the young leaves and

flowers they soon developed to such extent as to produce the characteristic discolorations.

In order to test the effect, if any, of sulphate of copper and liver of sulphur upon the germination of the spores, the latter were sown in solutions of these substances having various strengths. It was found that a one-fifth per cent. solution of copper was sufficient to prevent the spores from germinating. A one per cent. solution blackened and shriveled the spores to such an extent that they were scarcely recognizable. The copper solution seems to destroy the vitality of the spores entirely, as the latter rarely germinate after being exposed a very short time to the action of the substances. Liver of sulphur gave practically the same results as the sulphate of copper; some of the spores germinated in a one-fifth per cent. solution of this substance, and further investigation showed that very few developed in a one-twentieth per cent. solution.

IV.—TREATMENT.

A knowledge of the nature and habits of the fungus of brown-rot enables us to suggest several methods of combating it. In the first place the fruit killed by the parasite, whether cherries, apples, or peaches, should not be allowed to remain on the tree over winter as we have already seen that every one of the apparently lifeless fruits harbors many thousand spores. As soon, therefore, as the leaves have fallen all of the shriveled fruit should be removed from the tree and destroyed either by burning or burying. It would also be well to burn all the old leaves, twigs, and fruit that may have accumulated beneath the trees.

It is very probable that many spores of the fungus live over winter in the crevices of the bark, and in order to destroy these the trees should be sprayed in the spring, before the buds have commenced to expand, with a solution made by dissolving 4 pounds of sulphate of iron in 5 or 6 gallons of water. About the time the flowers are opening the trees should again be sprayed, this time using a solution of sulphuret of potassium, one-half ounce of the potassium to the gallon of water. A second application of this solution should be made at about the time the cherries are beginning to form, repeating the operation at intervals of two weeks until the fruit begins to color.

For applying the foregoing preparations a good force-pump fitted with spraying-nozzles is required. The Nixon pumps and nozzles manufactured at Dayton, Ohio, will probably be found as cheap and efficient as any in the market for this purpose. These machines, together with others designed for similar work, have been quite fully described by Professor Riley in a number of preceding* reports of this Department.

5.—The Powdery Mildew of the Cherry.

Podosphæra oxycantha (D. C.), DeBary.

(Plate VII.)

I.—GENERAL REMARKS.

Among the parasitic fungi which attack cultivated plants the powdery mildews or *Erysipheæ* hold a prominent place; the native vegetation is also much infested with them and it is very probable that

* Annual Report 1881-'82; Bulletin No. 10 Entomological Division, p. 57.

in many cases they have been transferred from the latter to the former. Like many of the members of this group the powdery mildew of the cherry attacks plants belonging to several genera, and it is also somewhat variable in its microscopic characters. These facts have led botanists to give it a number of names.

History.—It was first named and described by De Candolle,* who found the species on the hawthorn (*Cratægus oxycantha*) and called it *Erysiphe oxycanthæ.* Later DeBary † with a different understanding of the genus changed the name to *Podosphæra oxycantha.* Wallroth,‡ a German botanist, described the same fungus on the species of *Prunus* (cherry) as *Alphitomorpha trydactyla*, and De Bary§ afterwards made this name *Podosphæra trydactyla.* The form on the huckleberry (*Vaccinium*) was also described as distinct and named *Podosphæra myrtillina* (Schubert) Kunze. The form on *Spirea* was considered a good species and named *Podosphæra minor* by Howe.‖ Earle, in a revision of the American forms of *Podosphæra* and a comparison of the European has shown¶ that all these belong to one widely variable species whose characters nevertheless are as well defined as several other species of the group. Still later Miss Martha Merry** demonstrated that the so-called *Microsphæra fulvofulcra* described by Cook from California specimens on *Spirea*, is identical with the form on the same genus of host plants called by Howe *Podosphæra minor.* In the selection of the name for the species as a whole the oldest available name, *Podosphæra oxycantha,* the one for the form on *Cratægus*, was chosen.

Host plants and distribution.—This fungus occurs commonly in the eastern and central portions of the United States, and is reported from the Rocky Mountains and California.

Young cherry trees are the chief sufferers from its attacks, but it also does considerable harm to the peach and to young apple trees in the nursery, and occasionally seriously injures the quince. It is of very common occurrence, but fortunately does not usually get under headway until the trees have made their growth and are past serious injury. The fungus has been found on the following host plants, all of the order Rosaceæ, except the species of *Vaccinium* and persimmon:

Red cherry (*Prunus cerasus*), Garden plum (*P. domestica*), Wild red cherry (*P. Pennsylvanica*), †† Wild red and yellow plum (*P. Americana*), Small bird-cherry (*P. padus*), Sloe or blackthorn (*P. spinosa, P. demissa*), Choke cherry (*P. Virginiana*), Peach (*P. persica*), Apple (*Pirus malus*), Crab apple (*P. coronaria*), Quince (*Cydonia*), English Hawthorn (*Cratægus oxycantha*), Hardhack (*Spirea tomentosa*), Meadow sweet (*S. salicifolia*), Douglas's Meadow sweet (*S. Douglasii*), Shad-bush (*Amelanchier Canadensis*), Blueberry (*Vaccinium myrtillus, V. uliginosum*), Persimmon (*Diospyrus Virginiana*).‡‡

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* Flore Franc., VI, p. 106.
† Beitrage III, p. 48.
‡ Flore Crypt. Germ., III, p. 753.
§ Beitrage III, p. 48.
‖ Bulletin of Torrey Botanical Club, V, p. 3.
¶ Botanical Gazette, IX, p. 24.
** Botanical Gazette, IXI, p. 189.
†† Found by the writer on this host in Illinois, September, 1888.
‡‡ Rose, J. N. Botanical Gazette, XI, p. 61.

II.—EXTERNAL CHARACTERS.

The disease has been observed in Missouri as early as the 1st of June,* but usually it does not develop sufficiently to attract attention until July. During the latter part of summer and autumn it reaches its greatest development. It is first noticeable on the young leaves and tender shoots as small, round, or irregular, whitish blotches having a radiated appearance. The spots soon spread and run together, covering indefinite portions of the foliage or more often running over the entire leaf. As the fungus spreads the radiated appearance disappears. The threads meantime branch profusely and cross each other in all directions, forming an even white felt which may be very thin or so dense as to entirely conceal the green color of the leaf. The denser portions then become covered with a whitish powder, and still later the threads give rise to minute, black, spherical bodies just visible to the naked eye. The fungus grows on both sides of the leaf, in some cases indifferently on either surface, but usually a decided preference is shown for but one. On one tree the upper side of the leaves will be badly infested while the under side will have scarcely a trace of it; another tree, perhaps in the same orchard, and only a few feet away, will be badly mildewed on the under side with little on the upper. Frequently the black spherical fruits of the fungus are found abundantly on the leaves, usually the under side, with only a very scanty development of the white threads. From this condition very little damage results to the plant, and it does not present the characteristic mildewed appearance. Probably in this instance the leaf is pretty well matured before the fungus attacks it. On the other hand the principal damage to fruit trees results from the attacks on the growing tips and young leaves. Here the coating of the fungus is usually quite pronounced and the mealy appearance mentioned above is most prominent. This most destructive form of the fungus usually bears but a few of the spherical spore cases and often fails to produce any before frosts put an end to the season's growth.

III.—BOTANICAL CHARACTERS.

The white felt which creeps over the surface of the leaves is the vegetative portion or plant body of the parasite. It consists of slender, branching, septate, white threads, and is termed the mycelium. These filaments are about 4μ* in diameter. They do not penetrate the host, but send down small suckers, called *haustoria* (Fig. 5), into the epidermal cells. The fungus is entirely destitute of chlorophyll and depends wholly on the plant upon which it grows for its support. The haustoria absorb the juices from the host cells and transmit the material to the mycelium where it is used in the development of the fungus. As the development of the parasite proceeds certain rather thick branches called *conidiophores* arise from the mycelium and assume a vertical position. A transverse partition forms near the end of a branch, and the cell so isolated becomes somewhat rounded, and finally falls off. The spore thus formed is called a conidium (Fig. 4 *c d*). In the mean time similar partitions have been forming successively from the end of the filament downward, so that conidia occur in all stages of formation and give to the conidiophore a moniliform appearance (Fig. 4).

* Galloway.

* One $\mu = \frac{1}{25000}$ of an inch.

Some of the conidia reach a suitable place for germination and start the fungus in a new place. As the conidia are exceedingly small they are carried about by currents of air or by insects to adjoining trees.

These spores serve for the rapid spread of the fungus during summer. Later in the season, usually during summer, the dark colored spore-bearing bodies called *perithecia* develop at points where two filaments cross. Like the seeds of higher plants their development is the result of an act of fertilization.

The young sporocarp or perithecium is colorless, or nearly so, but as it grows larger it becomes yellowish, finally brownish, and when mature it is very dark brown or nearly black and opaque.

The fully developed perithecium (Fig. 1) is spherical when viewed from above, but the side toward the leaf is much flattened, so that the object represents slightly more than half a sphere. The surface is covered with numerous reticulations which indicate the cells of which it is made up. Each cell is rounded outward, so that the perithecium is covered with hemispherical protuberances or blunt conical projections. From some of the cells of the upper part of the perithecium arise peculiar outgrowths or appendages, characteristic of the *Erysipheæ*. They are septate, that is, consist of several cells, the lower of which are tinted brown while the upper and longer cell is colorless. This ends in a peculiar dichotomously branched tip (Fig. 2). While many of the appendages are highly developed and several times branched, others have this character but slightly developed, or entirely wanting, and end in a blunt point. The appendages vary in number from eight to twenty; sometimes there are only three or four. They are usually arranged in a circle around the upper part of the perithecium, but are sometimes clustered at the top and extend upward in an oblique direction. The perithecium contains a single, large, transparent spore sack (Fig. 3 *a*) called an *ascus*, in which may be seen eight elliptical ascospores (Fig. 3 *b*). With the exception of the thin places in the walls of the asci at each end there is no provision for the escape of the spores except by the breaking up of the perithecia the following spring from decay.

Little has been ascertained concerning the germination of these spores or the processes by which the fungus first starts on the leaf.

In many of the specimens examined small bodies were found resembling perithecia, but more delicate, thinner walled, lighter colored, and made up of smaller cells (Fig. 6). These are not of a constant size or shape, but were usually ovate or elliptical, and under pressure discharge from the apex numerous small elliptical spores (Fig. 6). They were supposed for a long time to be a part of the fungus, that is, one kind of its spore-producing bodies, but are now known to be a parasite on the mildew. We have here, then, a case of a parasitic fungus growing on another parasitic fungus. This parasite was first discovered by Cessati, who found it in connection with the grape mildew, and called it *Ampelomyces quaqualis?* This opinion was overruled and the fungus was considered one of the fruiting forms of the mildew until DeBary investigated it and demonstrated that it was a parasite on the mildew and not a part of it. DeBary named it *Cincinobolus Cessatii*. It occurs on various species of *Erysipheæ*, and was found quite commonly on the specimens of *Podosphæra* examined. In one instance a leaf supposed

to be covered with the perithecia of *Podosphæra* showed upon examination only the smaller, lighter-colored perithecia of *Cincinobolus*. In many instances it doubtless greatly prevents the spread of the mildew.

Conditions favoring the development of the fungus.—The members of this family thrive best during warm, dry weather, and the species under consideration seems to be no exception to the rule. In the Mississippi Valley vegetation suffered greatly from drought during the years 1887 and 1888, and in consequence the mildews had an unusual opportunity for development. In the latter year the cherry fungus was very abundant in Illinois, doing considerable damage to young trees. A light rain, giving the conidia a chance to germinate, followed by a long, dry spell, is probably the best time for the fungus to develop. On the other hand seasonable rains and other conditions favoring the proper growth of vegetation are probably the conditions least favorable to the parasite. It is a question whether the greater development of the mildews during a dry season is due to the direct action of these conditions on the fungus itself, or whether the explanation is to be found in the weakened vitality of the host. Both these influences must probably be taken into account. Plant parasites, however, have a way of appearing very abundantly in certain seasons and in certain places without any evident reason.

V.—TREATMENT.

On account of their manner of growth, which as we have seen is almost entirely on the outside of the leaves, the powdery mildews are easily reached and destroyed by fungicides. So far as we are aware no experiments have been made with the view of finding a remedy for the species under consideration, but as the powdery mildews are much alike in their structure and mode of growth it is reasonable to suppose that the treatment would be similar for all.

Sulphur, as is well known, has been successfully used in the treatment of the powdery mildew of the grape and rose, and it would no doubt be a successful remedy for this species. The material must be in a finely powdered condition and be dusted over the diseased parts.

From the numerous liquid fungicides the following have been selected as most suitable for use in this case, principally on account of their success in combating the mildew on the grape and rose. They are recommended in the order in which they are given, and should all be applied to the plants in the form of a fine spray.

Sulphuret of potassium (Potassium sulphide).—Simple solution in water. About one-half ounce to the gallon. Experiments conducted by the Section this year (1888) show conclusively that this remedy will not only prevent the powdery mildew of the grape but will destroy it when under headway. At the New York Agricultural Experiment Station during the present year Mr. E. S. Goff has found it successful in the treatment of the gooseberry mildew.

Liquid grison.—Prepared by boiling 6 pounds of sulphur and 3 pounds of lime in 6 gallons of water until the whole is reduced to 2 gallons. Allow to settle; pour off the clear liquid and bottle it until used. For use mix one part of the liquid with one hundred parts of water.

VI.—BIBLIOGRAPHY.

Bessey: Erysiphei of the United States, p. 4.
Burrill & Earle: Parasitic Fungi of Illinois, p. 412.
Cooke: Handbook of British Fungi, Part II, p. 647.
Earle, F. S.: Botanical Gazette, IX, p. 24.
Fries: Systema Mycologicum, II, p. 238.
Howe: Torrey Bulletin, V, p. 3. *Podosphæra minor.*
Kirschbaum: Jahrbucher, p. 76.
Merry: Botanical Gazette, XII, p. 189. *Podosphæra minor*, Howe.
Peck: 24th Report, p. 100.
Rose: Botanical Gazette, XI, p. 61.
Saccardo: Sylloge Fungorum, I, p. 2.
Tulasne: Selecta Fungorum Carpologia, I, p. 202. *Erysiphe oxycantha*, p. 201. *Erysiphe tridactyla*, Plate IV.
Winter: Die Pilze, I, p. 273.

6.—LEAF-BLIGHT AND CRACKING OF THE PEAR.

Entomosporium maculatum, Lév.

(Plates VIII, IX.)

I.—GENERAL OBSERVATIONS, ETC.

During the past year the Section has received many inquiries concerning a disease long known to horticulturists as "leaf-blight" or "scald" of the pear tree. It is quite distinct from the ordinary "pear-blight" and affects the fruit and wood as well as the leaves. It is extremely destructive in some parts of the country and merits special attention.

Effects and losses.—In this connection some extracts from correspondence may be of interest.

Letter from W. W. Thompson, Smithville, Ga., May 28, 1888:

> The trees (Le Conte) are five years old and 15 feet high, set in a circle 15 feet in diameter containing twenty-one trees. Nearly all the leaves have dropped from one-third of the trees, yet the wood looks sound and green. I find the disease is extending round the circle.

Ibid., July 24:

> So far the disease is limited, though I find it more extensive now than a few months previous. It has extended to a slight degree to my regular orchard. On some trees a portion of the lower leaves have fallen, and in several cases several limbs are as bare as in the fall, but, as I have said, this is only to a limited extent.

Ibid., October 31:

> The spotted leaves have increased very much since I first wrote you. The fruit is not injured nor are the trees to any extent except in growth and appearance. Last year I did not notice it at all here but did in Thomasville, and I have been there this summer and find it on most of the trees in the town, more than in the country. Some were nearly leafless in August. * * * The young leaves within 12 inches from the end of the limb do not seem to be affected. * * * Trees about towns and homes seem to be the worst, though I have seen even the center of my orchard affected; in fact all the trees are diseased to some extent, but most of them on the lower leaves only. When badly affected the leaves fall two months or more too early.

Letter from Mr. F. S. Earle, Cobden, Ill.:

> The premature falling of the leaves due to the attacks of the Leaf Blight fungus often causes great damage. I have seen an orchard of 3,000 Louis Bonne trees as bare by the 4th of July from this cause as they should have been by Christmas. The fall rains brought out a new set of leaves, and such fruit buds as were already formed bloomed, thus destroying the chances for a crop the following year.

Letter from Col. A. W. Pearson, Vineland, N. J., October 25, 1888:

> The leaves have all fallen except those of the Kieffer pear. * * * Other varieties of pear infested with the disease are denuded of their leaves fully six weeks be-

fore frost. * * * I think that with those sorts worst affected the damage in this region amounts to 75 per cent. It is an injury difficult to estimate, as the trees are denuded prematurely of their leaves, and then, of a late autumn, they are apt to open a premature bloom, and this detracts from the crop of the ensuing year.

The statements comprised in these letters show that the disease exists with different degrees of severity in different localities, but they are unanimous in indicating that fruit growers have much to fear from the malady, and that prompt treatment is necessary. Seedlings are particularly subject to the attacks of the disease; in fact many nurserymen have been forced to entirely abandon the culture of pear stocks on account of it.

Hosts.—The disease is not confined entirely to the pear, although it is on this that it most concerns farmers and fruit-growers. It also attacks the *Cydonia* (quince), *Cotoneaster*, and *Mespilus*. Nearly every variety of the pear is subject to it, but some are more liable to its attacks than others.

Mr. F. S. Earle says that "out of an experimental orchard of a hundred and twenty varieties planted at Cobden, Ill., all but ten or twelve were so badly injured as to be discarded as worthless." In a letter, from which we have before quoted, Col. A. W. Pearson says: "The Kieffer seems to best withstand the fungus. * * * The varieties most damaged are the Sheldon and Beurre Clairgeau. Both of these have been an entire loss for four years past. Every fruit has shriveled and cracked." In quotations already made from letters of F. S. Earle and W. W. Thompson, it is evident that the Le Conte and Louis Bonne are also very liable to attacks. From our own observations we conclude that Louis Bonne, Bartlett, Seckel, Bosc, Clapps, and Roestiezer are never entirely free from the disease and are usually badly attacked, while Anjou, Duchess, Lawrence, Flemish, and Vicar may be mentioned among the varieties most exempt.

Geographical distribution.—As has already been shown the pear and the fungus have nearly the same distribution. The disease has been reported on various hosts from Germany, Sweden, Italy, and France, and in this country it is very wide-spread.

History.—It was first discovered by Chaillet on living leaves of *Cotoneaster tomentosa* and *Mespilus germanicus*—two plants related to the quince and pear—and named *Xyloma mespili* by DeCandolle. Morthier afterwards found it on the first-named plant, also on *Pirus communis* and *sylvestris*, and Fuckel found it on *Cotoneaster vulgaris*. Fuckel gave it the name *Morthiera mespili*, including the fungus as found on all the above named hosts, and by this name it is still generally known. Saccardo, however, published only the form on *Mespilus germanicus*. Ellis and Cooke on the other hand founded the variety *Cydoniæ*, occurring on quince leaves and fruit, upon Fuckel's *Morthiera mespili*. Léveille changed the genus to *Entomosporium* and made two species, one *Entomosporium maculatum*, including the form on *Pirus communis*, and the other *Entomosporium brachiatum*, comprising the fungus on *Cotoneaster* and *Pirus sylvestris*.

In his Sylloge Fungorum, Saccardo attempts to reconcile these conflicting authorities as follows: He includes under *Entomosporium maculatum*, Lév., on *Pirus communis* the following varieties: (*a*) *domesticum*, equal to his former species (*Morthiera mespili*, Sacc.) on *Mespilus germanicus;* (*b*) *cydoniæ*, E. & C., on quince; and he changes *Entomosporium brachiatum*, Lév., to *Entomosporium mespili* (DC.).

The two species are founded merely on a difference in size of the

spores. According to Fuckel the conidia measure 14 by 18 μ. Sorauer gives the largest spores on *Pirus communis* as 22.5 by 10 μ, and Saccardo gives the following:

> *E. maculatum*, conidia 18–20 by 12 ; pedicel, 20 by ¾ μ.
> var. *domesticum*, conidia 18 by 8 ; pedicel, 15 by ¾ μ.
> var. *cydoniæ*, conidia 12–15 by 6–7 μ.
> *E. mespili*, conidia 25 by 15; pedicel, 20 by 2½ μ.

A careful comparison of these measurements will arouse some doubt as to their value as a basis for establishing species. Fuckel's and Saccardo's measurements might indicate some constant differences in size between the two species, but Sorauer's measurement of 22.5 by 10 μ on *Pirus communis* does not fall much short of Saccardo's 25 by 15 μ on *Pirus sylvestris*, and according to Saccardo's own measurements there is more difference between the species *E. maculatum* and its var. *cydoniæ* than the two species *E. maculatum* and *E. mespili*.

Furthermore, measurements of spores from the cultivated pear, made in this Department, indicate that their size may exceed the largest measurement given by Saccardo for *E. maculatum*. In fact, the founding of species on the size of spores, especially when the differences are so slight as in the present instance, needs repeated observations and measurements under varying conditions before much dependence can be placed upon it; and this is one case where the required number of observations have not yet been made. In fact, even if the variations given prove to be constant, it still remains to be proved whether they are not due simply to a change of host. The question is an extremely practical one, for, if farmers must expect infection from sources outside their own and their neighbors' pear trees, it is necessary that they should know it.

In Europe the fungus has been known for nearly a century. De Candolle mentions it in 1815. In this country the injury resulting from the disease has been discussed by fruit-growers for many years. In "Barry's Fruit Garden" for 1863 the author, in speaking of the difficulty connected with the growing of pear seedlings, says:

> This difficulty is owing chiefly to a species of rust or blight that attacks the leaves of the young plants, very often before the latter have completed their first season's growth. * * * It appears on the leaves in July or August first as small brown spots; these spread rapidly over the leaves until they are completely dried up and growth is stopped. Whether it is an insect or fungus, or some atmospherical cause, that produces this blight is unknown. Certain causes favor one or the other of these opinions. More minute investigations are wanted on the subject.

II.—EXTERNAL CHARACTERS.

The disease makes its appearance early in the spring soon after the development of the leaves. It first shows itself in the shape of small, dull, carmine-red spots which appear first on the upper, and finally penetrate to the lower surface of the leaf; the color soon changes from red to a dark brown, with a slightly elevated, minute, black spot in the center (Pl. VIII, Fig. 1). The spots also increase in size, and if they are very numerous, as is most often the case, the tissue between them also turns brown and loses its vitality. If the leaf is young or belongs to a delicate leaved variety it shrivels up by the contraction of the diseased portions; but if it is mature and consists of firm tissue it retains its shape, the only change being in the color. As soon as the leaf becomes badly diseased it falls off; and if, as often happens, another growth of leaves is produced, these too

become diseased. The spots are usually about three millimeters in diameter.

Trees seriously attacked by this disease can be distinguished at a distance by their defoliated appearance. This wholesale destruction of the foliage interferes very seriously with the growth of the wood and the maturing of the fruit, for the leaves are the organs which transform the food material that is brought up from the roots and absorbed from the air, into a form in which it can be directly used by the plant in the making of wood and production of sugar in the fruit.

But, in addition to this, the fruit and stems themselves often become diseased. The fruit also shows the carmine-red spots, which afterward become dark colored. The skin becomes very much roughened, and the growth of the epidermis over the diseased portion is checked, causing a crack which extends deeply into the flesh (Fig. 2), so that, even if the fruit can obtain sufficient sugar to mature properly its appearance is spoiled, and the cracking makes it liable to decay.

The development of the fungus on the branches does not differ materially from what takes place on the leaves. There first appear small circular spots on the young bark; these gradually become elongated and somewhat depressed with a slight elevation in the center, and their color changes to a shining, brownish black. Frequently the stem is completely girdled by these diseased areas, and as a result the end of the branch dies above the point where the fungus is present. The petioles and leaf scales are also often diseased. Indeed there seems to be no part of the tree above ground that is in active growth quite exempt from the attacks of the parasite.

III.—MICROSCOPIC CHARACTERS.

The small black specks in the center of the brown spots comprise the fruiting portions of the fungus. The fruit is at first covered by the cuticle, but this is finally ruptured exposing a layer of spores borne on a thin stroma (Plate IX, Fig. 1). The spores or conidia are analogous to the seed of higher plants; they have an exceedingly characteristic form, and may always be recognized without difficulty. When mature, they consist of from four to six cells, and are borne upon a pedicel or stalk. Their development is as follows (Fig. 2): short branches consisting of three or four somewhat elongated cells grow up from the stroma. The upper cell first shows an enlargement and this is followed by the second one which usually constitutes the lowest cell of the conidium, the remaining ones forming the pedicel. From the upper one of these cells grows out a fine, upright bristle which is about the length of the cell itself. It has distinct walls and contents, as may be seen by staining with iodine. Before these two cells are fully developed small buds may be seen growing out on the lower one, close to its point of contact with the upper. These vary in number from one to four. They grow out obliquely, so that they are in contact with the upper cell. In size they are much smaller than either of the others. From these in turn there grow out bristles, but in this case the bristles are on the backs of the cells and are directed horizontally, or obliquely. Occasionally three cells of the original filament swell up to form the conidium, and in this case both the lower cells may bear buds, or the lower one may branch and bear another conidium, so that one pedicel bears two conidia.

When the conidia germinate the cells enlarge somewhat and the bristles swell up at the base; the colorless, and sometimes septate, germ-tube frequently emerges in the vicinity of the bristle. When germination takes place on a leaf the germ-tube bores through the epidermis and develops a mycelium within the tissues.

The mycelium is composed of short cells forming colorless branching filaments. It is very abundant and is everywhere easily seen between the cells of the body of the leaf (Fig. 1). When young it penetrates the epidermal cells only, but Sorauer says that when it is old it becomes darker colored and can be seen within the cells of the mesophyll; and Ericksson states that he has found Sorauer's observations true in every respect. The mycelium masses itself together in places between the cuticle and epidermis, forming a thin stroma on which the conidia are borne. Below the stroma the mycelium seems at first to pass mainly between the epidermal cells, but it finally breaks them down so completely that the walls and contents can with difficulty be distinguished. The cuticle is finally ruptured by the pressure of the stroma and young spores, and the conidial layer is exposed to the air. Sorauer says that on August 4, 1876, the upper surface of the leaves of five one-year old pear seedlings were inoculated with these conidia and placed in moist air under bell jars. Three of the inoculated leaves, on two plants, showed the characteristic circles at the points of inoculation August 19, and a conidial pustule in September, giving about a month for the complete circle of reproduction.

In addition to the conidia Sorauer has also found what he considers the ascosporous or winter stage of the fungus (Fig. 6). The following is abridged from his account:

An investigation of the diseased leaves in December will disclose brown capsules on the tissues in addition to the still living conidial layers. These capsules (perithecia) I consider as the fruit of *Morthiera*, which attains maturity in May and June. The perithecia vary considerably in size. They are dark brown, globose or depressed from above, usually solitary, sometimes in groups of several ranging from 75μ to 175μ, and in some instances to 200μ in diameter. They are usually found either on the upper surface between the separated palisade cells or between these cells and the epidermis. In the first case they are not recognizable on the outside. In the latter there is a distinct swelling caused by the epidermis being lifted up by the growth of the capsule. The brown wall of the capsule varies in thickness, the greatest width being about 7.5μ. In January the best developed perithecia contain at their bases a mass of white, stromatic, small-celled tissue, from which arise numerous nearly upright, slender threads ranging from 1.5μ to 2.5μ in diameter. These are the young asci.

The asci are club-shaped, with a double contour, much the largest in the upper third of their length, and contain eight colorless, crowded ascospores, in two rows (Fig. 6 *a*). They are somewhat shorter than the paraphyses, and at maturity are obtusely conical in the upper portion, the point being drawn out into a papilla. This projecting point opens, forming a circular aperture through which the spores are discharged one after another (Fig. 6 *b*).

The paraphyses arise in a tuft from the base of the capsule; they are filiform to club-shaped or globose at the apex (Fig. 6 *e*), and are occasionally borne in pairs on one pedicel.

The spores are acute ovate to obtuse club shaped, divided into two parts by a transverse septum sometimes slightly curved and somewhat constricted at the partition (Fig. 6 *a*). When seen in large numbers the ripe spores have a pale, yellowish-brown appearance. They sometimes germinate while still in the ascus. In germination the hypha usually proceeds from the smaller end (Fig. 6 *c d*).

Their germination was observed in May at about the time the first diseased spots appeared upon the new foliage. So that if the conidia fail to carry the fungus over winter, or if they do not find a lodgment on the young stems, the ascosporous fruit will pass the winter unharmed and be ready to begin its work with the unfolding of the leaves.

Sorauer further classifies the fungus as a *Stigmatea* and gives it the specific name of *mespili*.

So far as known to us this has not been verified by any other observer.

There are several other fungi found associated with the *Entomosporium* on the pear and quince, and prominent among them is the one figured on Plate IX, figs. 4, 5. It is frequently found on the same spots with *Entomosporium*, but is often quite separate from these spots; it is especially frequent where the leaf is so badly diseased that the tissues are nearly all dead.

At first this appeared so closely connected with the *Entomosporium* that it seemed as if it might be the spermogonial form, but a closer examination revealed morphological differences in the mycelium. That of the spermogonial form is darker colored, thicker walled, contains distinct globules, and is not so closely septate or abundant. Moreover, this form is often widely separated from the conidial form of the *Entomosporium*. It is probably saprophytic in its nature, coming on the leaf after the *Entomosporium* has killed it. These capsules are found alike on both sides of the leaf, but more often on the upper side. They consist of a single layer of dark colored pseudo-parenchyma, lined with a little colorless tissue on which are borne chains of minute rod-like bodies (Fig. 5). These are so small that they partake of the Brownian movement.

IV.—TREATMENT.

It is difficult at any time to treat large trees, but as this fungus causes the greatest injury to young ones, and especially those growing in nurseries, a course of treatment that would be of use in the latter place alone would be of great value. From what we know of the life history of the fungus it is evident that burning the fallen leaves would serve as an important means of removing a source of infection. With regard to the proper time to do this it is probable that the best results will follow if the leaves are raked together and destroyed as soon as they fall; in other words, it would not be advisable to allow such leaves as may fall in midsummer from the effects of the malady to remain on the ground under the trees until the following autumn or spring. They should be destroyed as quickly as possible, before any of the spores have had an opportunity to escape.

Patrick Barry,* speaking of this disease, says:

> To obviate the difficulty which this malady presents [in the nursery], a vigorous growth should be obtained early in the season. New soil or that in which trees have not before been grown should be selected—an old pasture is the best. The autumn before planting it should be trenched or subsoil-plowed to the depth of 2 feet, for the pear has long tap-roots, and liberally enriched with a compost of stable manure, leaf mold, or muck and wood ashes in about equal parts; 4 inches of this spread over the surface before plowing, will be sufficient for ordinary soil. Lime should also be given liberally unless the soil be naturally and strongly calcareous. A soil prepared thus in the fall will require another plowing or spading in the spring to mix all the material properly with the soil and fit it for the seeds. If the soil be very tough, and not fit to be turned up, a thorough harrowing or working with the horse hoe will do. Where large quantities are grown the drills may be the same distance apart as that recommended for apples, 3 feet; but if only a few, 12 to 18 inches will be sufficient as the cleaning can be done with the hoe. The seeds should be scattered thinly, so that every plant may have sufficient space without any thinning. The end to aim at, as

* *Fruit Garden*, p. 127, revised edition.

before remarked, is to get good growth, say 18 or 20 inches in height and stout in proportion, before the 1st of August. This can be done in any deeply trenched or plowed fresh soil, well prepared and manured, as described above. I have been told that seedling pears grown in a frame covered with whitewashed sash and kept well ventilated continually escaped the "leaf-blight," whilst all those grown in open ground near by were blighted.

In addition to the foregoing it is very probable that the development of the fungus upon the leaves or other parts of the plant may be prevented by the application of some fungicide, although no experiments having a bearing upon this question have, as far as we know, been undertaken. Since the spots make their appearance as soon as the leaves have attained full growth the applications must be made early so as to prevent the spores from germinating. In no case should the application of the remedial agents be postponed until the fungus has made its appearance upon the leaves, for if this is done it will be of little use to apply them.

Where the disease prevails more or less every year it would be well to thoroughly spray the trees, before the buds begin to swell, with the Bordeaux mixture, prepared as follows:

Dissolve 16 pounds of sulphate of copper in 22 gallons of water; in another vessel slake 30 pounds of lime in 6 gallons of water. When the latter mixture has cooled pour it slowly into the copper solution, care being taken to mix the fluids by constant stirring.

When the leaves are about two-thirds grown a second application should be made, this time, however, using a solution containing the ingredients in the following proportions:

Sulphate of copper	pounds	6
Lime	do	6
Water	gallons	22

Dissolve the copper in 16 gallons of water and slake the lime in 6 gallons, then mix as described above. For applying these preparations an apparatus including pump, spraying-nozzle, etc., is necessary, and for small trees, especially those in the nursery, the machine known as the Eureka Sprayer, manufactured by Adam Weaber, of Vineland, N. J., will be found as efficient as any. With this machine a man can rapidly and thoroughly spray trees from 12 to 14 feet in height, but for large trees a pump having greater power will be required.

The object of the first spraying is to destroy any spores of the fungus that may have survived the winter in the crevices of the bark, while the second and weaker application is obviously for the purpose of preventing such spores as may fall upon the young leaves from germinating. It would be well to repeat the applications of the weaker solution every three or four weeks until the last of July or middle of August. The same preparations mentioned above may be used to protect the leaves of seedling pear trees against the ravages of the parasite, but in this case the first application of the Bordeaux mixture, second formula, should be made about the middle of June, followed by a second two weeks later, and a third the latter part of July. If this course of treatment is properly carried out we have little doubt that the plants will preserve their leaves throughout the season, and thus be able to complete their growth, making good stocks either for budding or grafting.

V.—BIBLIOGRAPHY.

Arthur: Rep. of N. Y. Experiment Station, III, p. 371, and IV, p. 276.
Barry, P.: The Fruit Garden; 1863, pp. 111 and 362; revised edition, pp. 127 and 451.
De Candolle: Fl. Fr.; VI; p. 158.
Cooke & Ellis: Grev.; VI; p. 84.
Earl, F. S.: Prairie Farmer; Feb. 12, 1887.
Eriksson, Jakob: Bidrag Till Kaennedomen Om Varra Odlade Vaexlers Sjukodomar. Contributions to the Knowledge of our Cultivated Plants. 1. Stockholm, 1885.
Field, T. W.: Pear Culture; p. 176.
Frank: Die Krankheiten der Pflanzen; II; p. 590.
Fuckel: Symb. Myc.: p. 382.
Grevillea: VI; p. 84.
Just: Bot. Jahresh. 1878; p. 462.
Léveille: Moug. Stirp. Vog. n. 1457.
Lukas, E.: Pomologische Monatshefte. Jahrg. 5; 1879; p. 176, note, and pp. 218, 219.
Maynard, S. T.: The Practical Fruit Grower; p. 49.
Meech, W. W.: Quince Culture; p. 176.
Saccardo: Syll. Fung.; III; p. 657.
————: M. V. n.; 525.
Sorauer: Ed. 2, Vol. II; p. 371.
————: Pomologische Monatshefte; 1879; pp. 176–178 and 217–218.
————: Die Obstbaumkrankheiten, Berlin; 1882; pp. 137–140.
Streinz: Nomenclator Fungorum; p. 662.
Thomas, J. J.: The American Fruit Culturist; p. 234.

7.—LEAF-SPOT OF THE ROSE.

Cercospora rosæcola, Pass.

(Plate IX.)

I.—GENERAL OBSERVATIONS.

This disease is quite distinct from the one that is generally known as black-spot, caused by the *Actinonema rosæ*, but it may occur on the same bush and even on the same leaf. Like the *Actinonema* it produces black spots on the leaves, and a superficial observer might consider it as the same disease, but a critical examination will bring to light very distinct and characteristic differences.

It is not generally so destructive to cultivated roses as the black-spot, but seems to prefer hardy kinds, especially the climbing species and varieties. This year it was very abundant on the wild roses in the vicinity of Washington. In many cases half of the leaves were affected and would fall to the ground when the plants were shaken. On the roses in the Department grounds, however, it was not present to any injurious extent.

Several years ago this fungus attacked about 2,000 large "Baltimore Belle" and "Queen of the Prairie" roses (climbers) growing in a nursery at Columbia, Mo., and by the middle of August nearly all the leaves had fallen. These plants, however, had not been pruned for two years, and had become so thickly matted together in consequence that the sun could reach only the outside leaves and branches. In September they were cut back to within 3 feet of the ground, the trimmings and leaves were burned, and the ground between the rows plowed and harrowed. The following year the leaves remained healthy throughout the summer. This was probably due to two causes: first, the removal of a source of infection by burning the diseased leaves, and plowing the ground so as to bury the spores that were scattered over the surface; second, the severe pruning allowed the sun and air currents to reach all parts of the plants, and

consequently they were probably kept too dry to allow the germination of any spores that might remain upon or be brought to them.

We have never observed the fungus on plants under glass except in the summer, when the sashes were removed.

II.—EXTERNAL CHARACTERS.

The disease first makes it appearance in the form of black or reddish black spots (generally the black shades into red at the edges); as the spot increases in size the center becomes light brown or even grayish. The reddish color usually remains at the edges. In the autumn the spots frequently remain small and the entire leaf becomes variegated with red and yellow.

The spots of *Actinonema* are always black from the beginning, and if the tissue around changes color it is to yellow or brown, not red. The spots of *Actinonema* are frayed at the edges while those of *Cercospora* are definite. Besides this, the center of the *Cercospora* spots often appears as if sprinkled with a white powder; this is not true of the *Actinonema*.

III.—MICROSCOPIC CHARACTERS.

This white appearance is caused by tufts of upright hyphæ which bear numerous whitish elongated spores. The tuft is represented in Plate IX, Fig. 7, with spores attached. These hyphæ or sporophores are brownish, borne on a stroma or rather knot of mycelium, and are frequently zigzag at the free end. The spores are long, septate, larger at the end where they are attached, and varying in length at different seasons (Fig. 8).

They are at first borne upon the end of the sporophore, but this grows out, leaving them a little behind and giving rise to another spore at the end. This process may be repeated, and each spore is left upon a notch at the side of the sporophore, giving the zigzag appearance already referred to.

The mycelium passes between the cells, and when a fruiting tuft is about to be formed a few threads push up between the epidermal cells and send out short upright hyphæ that rupture the cuticle. The stroma at the base continues to grow, and it finally pushes apart and breaks into the epidermal cells; the short sporophores meantime elongate and bear spores.

In the fall and upon wild roses the spots often remain quite small and seem to be perfectly sterile, but a section reveals that in many cases the fruiting tufts are immature, the cuticle is ruptured but the hyphæ have not elongated, and the stroma is not large enough to force the epidermal cells apart. Whether these immature hyphæ bear spores has not been ascertained.

IV.—TREATMENT.

A hint as to the method of treatment has already been given in the first of this article, and from the instance given there it would appear as if severe pruning, burning all diseased parts, harrowing the ground, and the choice of an airy, dry situation might be sufficient to avoid any serious consequences from this disease.

8.—PLUM POCKETS.*

Taphrina pruni, (Fckl.) Tul.†

(Plate X.)

I.—GENERAL OBSERVATIONS—HISTORY.

During the summer of 1888 the attention of the Section was several times called to a disease affecting the fruit of the cultivated plum. Letters were received from correspondents living in various parts of the country, stating that upon certain trees there were formed, instead of the normal plums, peculiar hollow deformities, consisting merely of a thin shell, with no evidence whatever of a seed. Specimens of these malformations were received from South Carolina,‡ Ohio, Kentucky, Kansas, and other States, with statements to the effect that upon many trees not a healthy plum could be found.

This disease is due to the presence of a parasitic fungus which attacks the young fruit, and by its growth within their tissues causes the peculiar development of the latter which finally results in the formations of the so-called "pocket."

It is evident that such remarkable growths as are produced by this fungus must have attracted the attention of both scientific men and practical fruit-growers long before the true cause of the trouble was known or even suspected. As long ago as 1593 an author by the name of Casalpin described the malady; but he offered no explanation as to its cause.

History.—For a long time the malformations were believed to be due to the work of insects;§ later it was suggested that improper fertilization might be the cause, and still more recently it was held that an abundance of moisture in the atmosphere, especially while the fruit was forming, would produce the deformities.

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* A number of names have been applied to these malformations by horticulturists, but the one here adopted is probably more generally used in this country than any other. In France the disease is known as "Lepre du Prunier." In Germany the pockets are called "Narren," "Shorten," etc., and in England "Plum Pockets" or "Bladder Plums."

† Synonyms:

Exoascus pruni, Fckl. Enumeratio Fungorum Nassoviæ, p. 29; No. 189.
Ascomyces pruni, Berk. Annals et Magaz. Nat. Hist.
Taphrina pruni, (Fckl.) Tul. Annales des Sciences Naturelles; ser. v, Tom. 5; 1866, p. 129.

‡ A correspondent from this State writes as follows concerning this disease: "I send you by this mail several diseased plums which I think have been stung by an insect. About nine-tenths of the fruit on one of my trees are affected like the specimens communicated. The tree which produced these monstrosities is of the Chickasaw type; two common wild plums grow quite near the diseased one, but their fruit is perfectly sound." (May 21, 1888.)

§ From the *Magazine of Horticulture*, Vol. VIII, 1842, p. 247, we quote the following from an article by Dr. T. W. Harris, author of several important entomological works. "Last year," writes Mr. Harris, "an undescribed disease of the plum made its appearance in some gardens of this vicinity, in the latter part of the month of May, and has been observed again during the present season. Soon after the blossoms had fallen the fruit began to swell rapidly, and in the course of two or three weeks it had grown to more than ten times the size that it ordinarily attains in the same period. It was soft and compressible, as though it were puffed up with air, being filled with an elastic, spongy substance of a whitish color. In some of these inflated plums no vestige of a kernel remained; in others, a little, soft, and empty shell was found. After growing from one-half to more than three-quarters of an inch in diameter the fruit dropped, and by the middle of June no more of it was to be seen on the trees.

"The cause of this puffy swelling of the fruit, and abortion of the kernel, is a little thrips; and several of these minute insects were found on the 28th of May on almost all the diseased plums. It is possible that they began their attacks in the blossom,

The real cause of the disease was discovered in 1861 by Fuckel, a European mycologist, who described the fungus under the name *Exoascus pruni*.* Three years later it was more thoroughly studied by DeBary, whose discoveries † concerning its life history have been verified by a number of subsequent writers on plant diseases. ‡

For a number of years the fungus retained the name given it by Fuckel, but by a later classification it became *Taphrina pruni*, (Fckl.), Tul. §

II.—EXTERNAL CHARACTERS, LOSSES, VARIETIES AFFECTED.

The "pockets" (Fig. 1 *a*) make their appearance soon after the flowers have fallen, attain full size and drop from the tree toward the middle or last of June. At first they are more or less globular in shape, but as they grow older they become oblong or oval and frequently more or less curved. They vary in size, but as a rule are from 1 to 2 inches in length and from one-half to 1 inch in diameter. When young they are nearly smooth and can be distinguished from the healthy fruit by their pale-yellow or reddish color. As they grow older the color changes to gray, the surface appearing as though it had been sprinkled with fine powder, and at the same time the pockets become wrinkled. Finally they turn black or dark brown, and rattle like bladders when brought in contact with any hard

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and that they prevent the impregnation of the ovule or young kernel by destroying the pollen; and by subsequently puncturing the plum, produce an irritation which is followed by a rapid swelling and diseased condition of the fleshy substance of the fruit. Preternatural enlargements and distortions of the parts of flowers and of fruits are known to be occasioned by the attacks of other species of thrips. This may be seen in the blossom of the black whortleberry (*Vaccinium resinosum*), all parts of which, calyx, corolla, stamens, and ovary, are sometimes enormously enlarged, and entirely changed in texture and appearance, in consequence of the punctures of a kind of thrips.

"It is not yet known how far this affection of the plum has extended. In this vicinity it seems to have been confined to certain trees only. Should the insects multiply and spread to other trees and other places, they will prove very destructive to the fruit hereafter. It remains therefore for the practical gardener to watch for their first appearance, and to devise some sure means of killing them, while the trees are in blossom and the fruit is forming."

* *Exoascus pruni*, Fckl. Sporidia eight, ovate or irregular, hyaline; asci erect, subclavate, obtuse; paraphyses three times shorter than the asci, irregular, hyaline. Densely covering the epidermis of the immature fruit of *Prunus domestica*. Enumeratio Fungorum Nassoviæ, 1861, p. 29.

† Beitr. zur Morphology und Physiologie der Pilze, 1864, p. 33.

‡ See Bibliography.

§ The genus *Taphrina* has lately been made the subject of a paper by Mr. B. L. Robinson (*Annals of Botany*, Nov., 1887), who, in speaking of its synonymy, says: "The species combined by Sadebeck, in 1883, into a single genus, were formerly classed in three closely related genera *Taphrina*, Fries, *Ascomyces*, Mont. et Desm., and *Exoascus*, Fuckel. Of these genera the first is the oldest, having been described by Fries as early as 1815 under the name of *Taphria*, which, to avoid possible confusion with an insect genus, was altered in 1825 to *Taphrina*.

"In this paper just mentioned Sadebeck has preferred, although without stating his reasons, to retain for the combined genus the youngest of the three names, that of *Exoascus*, Fuckel. Johanson agrees with Sadebeck in thinking that all the species should be combined into a single genus, but, seemingly with much more regard for the rules of priority in nomenclature, retains the name *Taphrina* of Fries. There appears to be all the more reason for this from the fact that, as early as 1866, Tulasne (Super Friesians Taphrinarum Genere, in Ann. des Sciences Nat., ser. 5, Tome V, 1866, p. 122) revised the genus of Fries and expanded its limits so that it might take in all the species then known of *Ascomyces* and *Exoascus*, thus using the name *Taphrina*, so far as the knowledge of the time enabled him, in the same sense as it is at present employed. From these considerations it seems best to follow Johanson in calling the group '*Taphrina*, Fries, char. a Tulasne emend.,' a sort of nomenclature which, if not brief, is yet in accord with priority and incapable of being misunderstood."

substance. They remain on the tree in this condition for two or three days, then fall to the ground and perish.

Sections through the diseased fruit show that the walls are quite thick, and that in place of a stone there is a large cavity filled with fungous threads and air.

The fungus often attacks the young branches and leaves, and when this occurs the injury is of course much greater than where the fruit alone is attacked. According to Mr. A. A. Crozier the fungus was abundant on the College farm at Ames, Iowa, the past season, attacking wild cherry (*Prunus serotina*) and several cultivated varieties of the wild plum (*Prunus chicasa*), being most prevalent on a vigorous grower and light bearer known as Maquaketa. Mr. Crozier further states that in his section it occurs mainly on the growing branches and leaflets, which become contorted and greatly swollen in consequence. About the time of the completion of the season's growth in June the diseased branches turn gray and the parts soon soften, then dry up and die. Shoots which arise the following year just below these dead extremities are most frequently affected by the disease.

So far as our observations have extended, the disease is never widespread in its effects; that is to say, it never sweeps over the country attacking all varieties of the plum alike, but on the contrary it often happens that a particular tree will bear nothing but "pockets," while adjacent trees of the same variety, grown under precisely the same conditions, show no traces whatever of the disease. It is difficult, therefore, to estimate even approximately the amount of injury the parasite occasions, but enough is known concerning its ravages to fully demonstrate its gravity.

As a rule a tree that has once borne a crop of the "pockets" seldom recovers, but continues with each succeeding year to produce a greater or less number of the malformations. All plums are more or less subject to the attacks of the parasite, but it is usually more abundant on the red and purple varieties. It also occurs in this country upon the wild red plum, *Prunus Americana;* the beach plum, *Prunus maritima;* the dwarf cherry, *Prunus pumila;* the wild black cherry, *Prunus serotina;* and the choke cherry, *Prunus Virginiana.*

III.—BOTANICAL CHARACTERS.

A microscopic examination of one of the diseased plums will show that the fungus occurring within the tissues consists of three parts, namely, (1) mycelium; (2) asci; (3) spores or reproductive bodies.

The mycelium or vegetative portion consists of colorless, septate filaments, which may first be seen in the soft bast of the fibro-vascular bundles that penetrate the flesh of the fruit. They multiply at first in the tissues of the "pockets," and afterwards pass towards the surface. Some of the hyphæ push up between the epidermal cells and spread out between these and the cuticle. Here by repeated branching and interlacing they form a net-work which is not more than one cell deep (Figs. 2, 3). The threads forming this net-work are composed of very short cells, not more than twice as long as broad, which soon start an independent growth at right angles to the surface of the pocket, forming small cylinders standing close side by side, but apparently unconnected (Fig. 4). They at first carry the cuticle upon their ends, but finally rupture it and appear on the surface. These bodies are the immature asci. They are at first filled with a rich granular protoplasm, which, as they increase in length, passes into their free ends and is cut off from the rest of the tube by a septum.

The portion above is now the ascus proper, and occupies about two-thirds of the length of the tube, the remainder constituting the pedicel. The protoplasm now rounds itself off into several, usually eight, spores (Fig. 6). These are colorless, globose, and about 4 μ in diameter. The mature asci are club-shaped, 40 to 60 μ long by 8 to 16 μ in diameter. They stand closely side by side, the pedicel supported upon the upper surface of the epidermal cells so that no part of the asci extends within the tissues.

The spores escape when ripe by rupturing the free end of the ascus. They germinate readily in water by the formation of an excrescence or bud, which soon assumes a shape about like that of the parent spore. The daughter spore in turn gives rise to a second bud like the first, and this process continues for several generations, or until the nourishment in the fluid is exhausted. If mature spores are detained within the ascus germination frequently follows, and as a result the latter becomes filled with innumerable sprouts of various orders and sizes, which readily separate and escape as individual spores when the ascus is ruptured.*

From the foregoing facts it is seen that the fungus is abundantly able to propagate itself. Each "pocket" develops countless numbers of asci, and each ascus, as a rule, contains no less than eight spores, which upon germination give rise to several generations of daughter spores. Notwithstanding the ease with which the spores germinate, no one has succeeded in infecting healthy plums with them.

The mycelium of the fungus is found in the smaller branches in early spring before the diseased fruit appears, which seems to indicate that it may live from year to year in the tree itself; moreover, the annual recurrence of the "pockets" on the same tree furnishes additional proof of this fact.

The only course of treatment which a knowledge of the facts in the case suggests is to remove and destroy the "pockets" before they reach maturity. In doing this, it would seem to be well to cut back the branches so as to destroy all the parts which are likely to contain the mycelium of the fungus. Instances have come under our observation where this practice was followed for two or three years with decidedly beneficial results.

IV.—BIBLIOGRAPHY.

Berkeley: Annales et Magaz. Nat. Hist. No. 1629; *Ascomyces pruni*, Berk.

D'Arbois de Jubainville et Vesque: Les Maladies des Plantes Cultivées; Paris, 1878, pp. 298, 299.

De Bary: Morphologie und Biologie der Pilze, I, p. 33, 1864; *Ibid.*, 2d edition, pp. 287, 288, 289; Comparative Morphology and Biology of the Fungi, Garnsey's translation, 1887, pp. 266, 267.

Frank: Die Krankheiten der Pflanzen; Breslau, 1880; p. 524; *Exoascus pruni*, Fckl.

Fuckel: Enumeratio Fungorum Nassoviæ, 1861, p. 29; *Exoascus pruni*, Fckl.; Symbolæ Mycologicæ, 1870, p. 252; *Exoascus pruni*, Fckl.

Harris, T. W.: Mag. of Horticulture, Vol. VIII, 1841, p. 247.

Johanson: Ofser sight af Kongl., Stockholm, 1885, p. 29.

Plum Bladders: The Garden, Vol. XXVIII, p. 19, 1885.

Robinson, B. L.: Annals of Botany, Vol. I, No. 2, November, 1887, p. 167; *Notes on the Genus Taphrina.*

Sadebeck: Jahresbuch der Wissenschaftlichen Austalten; Hamburg, 1883.

Sorauer: Pflanzenkrankheiten; Berlin, 1886; p. 274; Plate XI; *Exoascus pruni*, Fckl.

Tulasne: Annales des Sciences Naturelles, 1866, p. 129; *Taphrina pruni* (Fckl.), Tul.

Von Thümen: Fungi Pomicoli; Wein, 1875, pp. 88, 89, Plate I, Fig. 2; *Exoascus pruni*, Fckl.

Winter: Krankheiten der Culturgewachse; Leipsig, 1878, pp. 44, 45, 46; Rab. Crypt. Flora, 1885, II, p. 5; *Exoascus pruni*, Fckl.

*De Bary: Morph. und Biologie der Pilz., 1884, p. 289.

9.—APPLE RUSTS.*

(Plates XI, XII.)

I.—GENERAL OBSERVATIONS.

Orchard rusts have long been known as troublesome pests to the apple, quince, and other cultivated fruits, often doing much injury to the crop. It is not the present purpose to enter into a discussion of the destructiveness of these fungi, but assuming that their eradication is desired the allotted space will be occupied in outlining the present knowledge of the rust plants and suggesting remedies which have borne the test of trial, or may, in the light of a fuller understanding of the fungi, prove of advantage in diminishing their inroads upon an important industry.

As now understood, the apple rusts are forms of species of the genus *Gymnosporangium*, which live upon the cedars or junipers (*Juniperus* and *Cupressus*) in one stage and upon the apple in another. These two forms in the life history of the parasite are so very different in outward appearance that the early botanists classified them as distinct species in different genera. Those upon the cedars, as above stated, are *Gymnosporangia*, and the forms upon the apple are members of the old genus *Ræstelia*. As the condition upon the cedar precedes that upon the apple, in the cycle of life of the fungus, it is proper that we first confine our attention to the form upon the juniper group.

The genus *Gymnosporangium* is a member of the group *Uredineæ*, or true rusts, to which, also, belong *Puccinia*, *Uromyces*, *Phragmidium*, and a number of less-known genera, as well as the old form-genera *Uredo*, *Æcidium*, etc. The order *Uredineæ* is one of parasites, and many of them are particularly destructive to farm and garden crops. We have only to point to the wheat, oat, rye, and barley rusts, and those of many grasses and other crops, to convince the general reader that the groups to which his attention is called is one abounding in injurious species. An outline of the life history of the wheat rust may help in explaining the meaning of the term *form-genus*, and at the same time prepare the way for a more thorough understanding of the cycle through which the apple rusts pass.

The rust of the wheat was first named *Uredo linearis* and described as a distinct species. A rust upon the barberry was designated *Æcidium berberidis*, and another form of fungus upon the wheat was styled *Puccinia graminis*. Tulasne, thirty years ago, advanced the idea that the *Uredo* species were only early forms in the development of species of *Puccinia*. In 1863 De Bary† added the belief that the *Æcidium* species, so called, were likewise forms in the life history of *Puccinia*, *Uromyces*, and allied genera, and that they preceded the Uredo stage. De Bary's view was based upon a very careful study of the wheat rust. The spores found late in the season upon the wheat culms, and appearing as dark-brown patches, were germinated, producing small spores upon the tips of minute filaments. These sporidia De Bary found would not grow, except upon the leaves of

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* By Byron D. Halsted.

† Recherches sur le développement de quelques champignons parasites.—Ann. des Sc. Nat., 4, Ser. 1–20.

the common barberry, where they vegetated and produced in a short time the true barberry rust (*Æcidium berberidis*). The spores are borne in cups grouped together; hence the common name of "cluster cup" for the fungus. When the spores contained in the cups find their way to the blades of wheat, germination, quickly follows; the slender threads called mycelia or hyphæ penetrate the plant and there vegetate. In a short time a yellowish patch is produced, and the imbedded fungus by rupturing the epidermis exposes the orange dust characteristic of the wheat rust. Following the *Uredo linearis* is the final state, or *Puccinia graminis*, the one with which De Bary started.

It will be seen to follow from the pains-taking investigation of the celebrated German botanist that what were called distinct species become only forms of the same species, and were all the life histories of the various kinds of rusts known, it is probable that such genera as *Uredo* and *Æcidium* would cease to remain. They are retained to accommodate those forms, the genetic relationship of which has not as yet been determined. In deciding upon the name for the polymorphic fungus it is natural to select the final form; therefore, in case of the examples here briefly outlined, the species is *Puccinia graminis*, Pers., which includes all the stages. A common method of indicating the Æcidium, Uredo, and Puccinia (teleutosporic) forms is by Romam numerals. Thus whatever in the description of the species comes under I refers to the Æcidium state; under II to the Uredo, and III represents the final form.

Let us now glance at some of the distinguishing characteristics of the three forms above mentioned. The final spore formation called the teleutospore, in *Puccinia graminis*, as in all members of the genus *Puccinia*, is composed of two cells, usually very closely united by their bases and spoken of as a single spore. It is virtually a winter condition of the species, with the protoplasm condensed within and surrounded by thick protecting walls. These cells germinate in any moist place in spring, producing a slender filament usually somewhat branched, and finally bearing a small spore upon each tip. This first form of spore is not ranked as a distinct state, because it is simply the escaped condition of the vital substance of the teleutospore in a shape to facilitate the multiplication and easy dissemination, as well as penetration into the host of the essential part of the teleutospore. The *Æcidium*, as seen upon the barberry leaf, assumes in its full development a cup like structure with wall and contents. The portion of leaf which is infested is somewhat thicker than the normal parts, often of a yellow, orange, or even reddish color—and in this thickened patch develop the æcidia or cups. These form within the infested substance, and only become cup like when they rupture the epidermis, and the exposed end of the wall breaks irregularly and the edges turn outward, thus forming the minute cup, within which the multitudes of æcidial spores are borne in closely-packed rows, and upon this account are often quite polygonal. In the early stage of the development of this fungus in the infested portion of the leaf there are minute oval or flask-shaped organs called spermogonia, produced usually upon the opposite side of the leaf to that finally bearing the cups. Small oval bodies are produced within the spermogonia, but their function is not known—the conjecture has been simply that they take part in a process of fertilization not yet discovered. The most recent paper upon the

wheat rust is by H. Marshall Ward,* with excellent illustrations, which, with the classic contribution of De Bary previously cited, will give the interested student a full knowledge of the present aspect of the subject. In the Uredo state, upon the grass the fungus has no wall or cup consisting of its own tissue, but is made up of masses of threads which congregate under the epidermis, finally bursting it and exposing the elliptical, finely spinose, orange spores, borne singly and terminally upon long, slender stalks.

These uredospores quickly germinate and become the centers of mycelial growth for the production of pustules containing the final- or teleutospores which, in their general method of formation from the hyphæ and the rupturing of the epidermis, agree closely with the uredo form, except that they are not easily detached from their pedicels.

Having thus purposely repeated the essentials in the life history of a leading member of the genus *Puccinia*, the careful reader is prepared to enter upon a more elaborate treatment of an allied group of species.

II.—THE GENUS GYMNOSPORANGIUM.

This genus is in some respects closely related to *Puccinia*. These two, out of several genera in the group *Uredineæ*, are the only ones, for example, which have the teleutospores as a rule two-celled, as shown at Fig. 4 in Plate XII. The chief differences are in the time of year when the teleutospores are formed and the presence of a gelatinous surrounding to the spores. The pedicels or spore-bearing stalks are usually hyaline, more slender, and much longer in *Gymnosporangium* than in *Puccinia*, a necessary difference due to adaptation to the unlike conditions.

History of the genus.—The genus was founded by De Candolle in 1805.† Four years later Link‡ made a division based upon the shape of the gelatinous substance, placing those with cylindrical masses in *Podisoma*. This division was long retained, but is now generally considered as unnecessary. Of the nine species of the genus now known in the United States all are parasitic upon a small group of the *Coniferæ* or subfamily, the *Cupressineæ*.

Two species are confined to the white cedar (*Cupressus thyoides*); three inhabit exclusively the red cedar (*Juniperus Virginiana*); two have both of the above cedars for hosts; one upon common juniper (*Juniperus communis*) and one upon *Juniperus occidentalis* of the Rocky Mountains. All but the last are treated of, and with a master's hand, by Dr. Farlow,§ to whom the writer is under special obligations for matter used in this paper.

Characteristics of the species.—The species are founded upon the size, color, and approximation of the gelatinous, sporiferous masses, and the measurements, septa, color, number, and position of promycelia produced from each spore cell, and the character of the distortions of the host plant. The promycelia are the filaments which grow from the spore cells when they undergo the process of germination. At Fig. 5 in Plate XII is shown a teleutospore undergoing

* Illustrations of the structure and life history of Puccinia graminis, the fungus causing the "rust" of wheat.—Annals of Botany, Vol. II; p. 217; 2 plates.

† Flore Française, Vol. II.

‡ Observations in Ordinis plantarum, 1809.

§ The Gymnosporangia or Cedar Apples of the United States, from Memoirs Boston Soc. Nat. History 1880.

germination. A promycelium proceeds from each cell, and, branching, bears sporidia upon the tips.

The size of the gelatinous masses varies greatly among the different kinds. In most of the species the fungus is perennial and usually of a slower growth than with those living for a single year. This may account in part for the characteristic differences, for the hyphæ or vegetative threads of all the species are in themselves very much alike. Thus, in a slow-growing species with a small amount of mycelium there would naturally be less distortion for the same length of time than in a quick-growing annual species with a large percentage of mycelium within the tissue of the host. But even this attempt at an explanation does not render it clear why two species made up of almost indistinguishable filaments in equal amounts, and growing at the same rate over equal periods of time, should give rise upon the same tree, or branch of the tree, to widely different distortions of the host. In some of the perennial species the fungus lives mostly in the cambium layer and stimulates an excessive deposition of wood from year to year in the infested part until it becomes several times larger than the normal portion above and below the excrescence. Of such are the conspicuous swellings upon the branch of white cedar caused by *G. biseptatum*, Ellis. In others the mycelium spreads rapidly through the young twigs, robbing and dwarfing them until a dense tuft results unlike the healthy twigs of the cedar. The fanciful name of "Witches' Broom" is not inaptly applied to such distortions produced by *G. Ellisii* (Berk.), Farl. Other species are more local in their attacks and confine their work to a small cedar leaf, and the result is one of the so-called "apples," often soft in texture, due to the large percentage of hyphæ and the rapid growth of the gall-like structure. The response of the cedar plant to the stimulus induced by the young fungus is, perhaps, not unlike that following an insect's sting, and one is about as easy to explain as the other. The gelatinous, sporiferous masses vary greatly in size, color, and their proximity to each other. In *Gymnosporangium Ellisii* they are quite minute, almost invisible when dry, and of a reddish brown color, orange after a rain, when they are swollen by the moisture to nearly a quarter of an inch in length and scattered over the larger twigs composing the "broom-like" distortion. In *G. biseptatum*, above cited for its knotty excrescences sometimes several inches in diameter, the gelatinous, spore-bearing masses are borne in the cracks and fissures of the distorted stem as rugose, shapeless tufts of light yellow jelly. Other species have the spore-bearing, gelatinous outgrowths from the excrescence proper projecting for a considerable distance, often more than an inch, when swollen by prevailing moisture. In such there is a striking difference between the expanded form and the dry condition when the horns of jelly have dried down and almost disappeared.

Injury to the hosts.—All of the species of *Gymnosporangia* are injurious to the hosts but not in the same degree. It is not the most conspicuous species that necessarily effects the greatest injury. For example, a showy, rapidly growing annual may do less harm and be more quickly eradicated than a persistent, deeply seated perennial. If the destructive work of the species was confined to the cedars of various sorts there would be no serious complaint, but because in one form they trespass upon the apple, quince, and other closely allied cultivated plants, they are dreaded by the fruit-grower under the common name of "Orchard Rusts."

III.—THE ROESTELIA FORMS.

With this preliminary treatment of the first form of the species of *Gymnosporangia*, let us pass to a brief consideration of the second state, worse than the first; after which an injurious species is to be taken up for special inspection. The old genus under which the orchard rusts were classified by early botanists is *Rœstelia*. This corresponds with and is not very different from the genus *Æcidium*, which was treated of while considering the polymorphic nature of *Puccinia graminis*, and known commonly as the "cluster-cup" form, growing upon the barberry. The chief difference is in the size of the wall (peridium) of the cup, which in *Æcidium* is short, while among *Rœstelia* it is prolonged into a tube often several times as long as broad. In some species of the latter genus the cups or "horns" do not produce a fringed mouth at the top as is usual in *Æcidium*, but the cells of the peridium remain closed at the apex, and below separate from each other longitudinally, forming meshes for the escape of the spores.

These prolonged cups are borne usually in clusters upon the under side in thickened patches of the infested leaves or fruit of various pomaceous species of the order *Rosaceæ*, as for example the apple and quince. Some species frequently attack the young fruit and twigs and in developing greatly distort them. This is particularly true of *Rœstelia aurantiaca*, Peck., which infests several species of hawthorn (*Cratægus*), juneberry (*Amelanchier*), and apples and quinces. This is a very beautiful species having brilliant orange spores, suggesting the specific name, and when growing in a large succulent fruit is usually attractive to the eye, if one can overlook the damage that the fungus has wrought. Quinces have frequently been seen of more than half their natural size and almost entirely covered with the densely aggregated broad cups which bear their shining white peridia, recurved and exhibiting the masses of bright orange spores within.

The leading points in the classification of the *Rœstelia* are gross appearance of affected parts (Plate XI, Fig. 1), location, size, form, color, and proxmity of the æcidia; color, size, and markings of the spores and peridial cells, and location, number, and color of spermogonia.

The first indication of an attack of *Rœstelia* is a slight discoloration of the part, usually the leaf, followed by minute flask-shaped bodies, the spermogonia filled with minute free cells of unknown use. Soon after, usually upon the opposite side of the leaf, appear the æcidia which bear the spores (Plate XII, Figs. 2, 3) that when returning to the *Cupressineæ* develop the *Gymnosporangium* and thus complete the cycle of the fungus. As before stated, this relationship between the fungi upon the *Pomeæ* and the *Cupressineæ* was long ago suspected, but not until within a few years has the actual demonstration been furnished. Dr. Farlow was among the first in this country to take up the work in a systematic, scientific manner.

In "the Gymnosporangia, or cedar apples of the United States,"* he recognized eight species of the genus *Gymnosporangium* and an equal number of *Rœstelia*, but was at that time unable to fully establish the genetic relation between the two forms.

In February, 1885,† he concluded that *G. biseptatum*, Ell., and *R. botyrapites*, Schw., were probably connected; also *G. globosum*, Farl., and *R. aurantica*, Pk., and that *G. macropus*, Lk., had its *Rœstelia* on apples and *Amelanchier*.

*Memoir l. c. Boston Soc. Nat. History, 1880.

†Notes on some species of *Gymnosporangia* and *Chrysomyxa* of the United States. Am. Acad. Arts and Sc.

There are two chief means of gaining information upon questions of relationship in the forms of parasitic fungi; first, by studying with great care the geographical range of each form, and secondly, and most conclusively of all, by cultures. For example, if there is any considerable territory over which only one *Gymnosporangium* flourishes, and is followed by a single form of *Rœstelia*, it would not be unfair to suspect, at least, that these two forms were of the same species. Such facts as these have given strong hints to aid in the systematic culture of the forms. The time of maturing the spores also enters as evidence of no small value.

Thus, *R. botryapites* upon the *Amelanchier* is late in maturing, scarcely being ripe before October, while the cedar apples of *G. macropus* begin forming in early summer; therefore at the outset there is circumstantial evidence against these forms being genetically related. In this connection, however, it must not be forgotten that most *Gymnosporangia* are perennials and that the same may be true of the *Rœstelia*. Consequently the only entirely satisfactory method of determining the relationship is by culture, and this consists in growing certain *Rœstelia* upon the hosts and failing to grow all others, by repeatedly sowing the *Gymnosporangium* spores, under favorable conditions, while at the same time preventing access of any other kind of teleutospores.

Mr. R. Thaxter, a graduate student under Dr. Farlow, has been successful in this experimental work, and now with considerable confidence the connection between several species of *Gymnosporangia* and *Rœstelia* can be stated. Without attempting to give the details of Mr. Thaxter's paper* the summary of results is here repeated:

1. *G. conicum*, D C. = *R. cornuta* (Ehr.), Fr.
2. *G. clavipes*, C. & P. = *R. aurantiaca*, Pk.
3. *G. clavariæforme*, D C. = *R. lacerata* (Sow.), Fr.
4. *G. macropus*, Lk. = *R. pirata* (Schw.), Thax.
5. *G. biseptatum*, Ell. = *R. botryapites*, Schw.
6. *G. Ellisii*, (Berk.) Farl. = *R. transformans*, Ell., probably.
7. *G. globosum*, Farl. ?

If we construct another table giving the hosts for each form, as has been done by Professor Seymour,† it would indicate new points of interest:

1. *G. Ellisii*	White cedar	Pirus arbutifolia Cultivated apple	*R. transformans* 1.
2. *G. biseptatum*		Juneberry	*R. botryapites* 2.
		?	
3. *G. globosum* 4. *G. conicum* 5. *G. macropus*	Red cedar	Mountain ash Juneberry Hawthorn	*R. cornuta* 4.
		Crab apple Cultivated apple Juneberry	*R. pirata* 5.
		Hawthorn Juneberry Quercus	*R. aurantiaca* 6.
6. *G. clavipes*	Red cedar and Juniper	Cultivated apple	
7. *G. fuscum*		?	
8. *G. clavariæforme*	Juniper	Hawthorn Juneberry Wild and cultivated apple	*R. lacerata* 8.

* On certain cultures of Gymnosporangia, with Notes on their Rœstelia. Am. Acad. Arts and Sci., 1886, p. 259.

† Orchard Rusts, Vol. IV Am. Hort. Rept.

Among the *Cupressineæ* it will be seen that the red cedar is the favorite host, no less than four species infesting it. Of the *Pomeæ* the juneberry takes the lead with five species.

At least four species may infest the cultivated apple, namely: *R. transformans*, a form of *G. Ellisii* on white cedar (*Cupressus thyoides*), *R. aurantiaca*, of *G. clavipes* on red cedar (*Juniperus Virginiana*), *R. lacerata* of *G. clavariæforme* on juniper (*Juniperus communis*), and *R. pirata* of *G. macropus* on red cedar.

This should be borne in mind while we treat in detail of *G. macropus*, which is the species credited with causing the principal part of the rust of the apple orchard.

IV.—GYMNOSPORANGIUM MACROPUS, LK.*

This species (Plate XI, Fig. 2) is the common "cedar apple" of the United States, and during moist weather in spring produces conspicuous orange galls.

History.—It was first described by Schweinitz in 1882 as *Gymnosporangium juniperi-virginianæ*. In 1825 Link named it *Gymnosporangium macropus*, he having previously (1809) constructed the genus *Podisoma* to include those species possessing the gelatinous, sporiferous masses more or less conical or cylindrical. There is seemingly no good reason for his excluding this species from his new genus. In 1831 Schweinitz adopted Link's specific name, accepted his new genus, and called the species *Podisoma macropus*, Schw., by which name it has been generally known until within the last few years. Recent mycologists have considered that the mere shape of the gelatinous tufts is not generic, and being convinced that Schweinitz's original specific name was awkward and misleading, as four other species grow upon *Juniperus Virginiana*, by common consent the name here employed has been agreed upon. Schweinitz had himself already adopted Link's specific term.

Geographical distribution.—This species is found with its host over a wide range of territory, but not in equal abundance, wherever the red cedar grows. The introduction of the juniper into new localities has been followed by this parasite, so that the "apple" may be generally considered a quite constant accompaniment of the cedar.

External characters.—The "apple" or gall usually forms a somewhat kidney-shaped excrescence, attached by a small base on the concave side, and varying in size from a half an inch to an inch and a half in length. A careful search will reveal the first beginning of the enlargement some time in midsummer, much depending upon the weather previous to this time. The fungus attacks the leaves, and after vegetating for a time, develops a small external swelling of the size of a pin head upon one side. This continues to enlarge until the normal dimension is reached. A fully developed "apple"

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*Synonyms:
Gymnosporangium juniperi-virginianæ, Schw. Syn. Fung. Carl.; Sup., p. 74; No. 504; 1822.
Gymnosporangium macropus, Link. Sp. Plant; Vol. VI; part 2, p. 128; 1825.
Podisoma juniperi-virginianæ, Fr. Syst. Myc.; Vol. III; p. 57; 1832.
Podisoma macropus, Schw. Syn. Fung. Am. Bor.; p. 307; No. 3096. Sprague's Contrb. N. E. Mycol.; p. 329. Curtis Pl. N. C.; p. 121. Peck's 23d N. Y. Rept.; p. 57.
Exsiccata: Ravenel Fung. Car. 1; No. 85. Ellis N. A. F., 3; No. 270. Thüm. Myc. Unv.; No. 148.

seems often to be an outgrowth from the branch and frequently appears terminal upon the twig because the stem above it was crowded to one side or dwarfed and lost from view. When winter sets in these excrescences are of nearly full size, of a beautiful light chocolate color, and exhibit a uniform series of shallow pits.

Microscopic characters.—At this time the gall, in thin sections, under a high magnifying power is seen to consist of a mass of oval, thick-walled cedar cells packed together in an irregular manner, and ramifying among them are the hyphæ of the fungus. During the early spring, when moist warm weather comes, the threads of the "apple" congregate at the base of each of the circular disks, each thread developing a double spore upon its tip, at the same time secreting a large amount of jelly and pushing out a horn of orange-yellow, elastic, gelatinous substance (Plate XI, Fig. 2).

At this time the galls are most conspicuous, and the cedar trees when badly infested appear, after an April and May shower, as if in bloom, and, in fact, the soft excrescences are commonly known as "cedar flowers." While these horns are extended and before having dried down by fair weather the teleutospores (Plate XII, Fig. 4) undergo the process of germination (Fig. 5). When the gelatinous masses become shrunken by drying, the sporidia, formed upon the tips of the promycelia (Fig. 5 *a a*), are brought into a condition to be easily removed and carried away by the wind. When another rain comes new spores mature and undergo the same process of secondary spore formation. After the season's crop of spores has been produced the excrescence becomes almost as hard as bone, and soon loses its attachment to the tree. In other words, the *Gymnosporangium* with which we are now more especially concerned is an annual. The galls may remain upon the branches for more than one summer, but only as dry and dead knots after the first year, and the retention is merely accidental.

Conditions favoring the development of the fungus.—The time in the spring for the maturing of the spores is largely determined by the weather. This may be illustrated by citing some experiments carried forward two seasons ago. The galls were gathered upon April 12, and, before any gelatinous tufts were developed, placed in water in a warm room; and on April 23 the sporidia were ripe and in great abundance. By this artificial heat and constant supply of water the fungus was forced at least three weeks ahead of its time. There is no doubt that a cold, dry spring retards the development of the cedar apple as much as opposite conditions tend to push it forward. In 1887 there were two distinct crops of the Rœstelia upon the wild crab (*Pirus coronaria*) on the college grounds (Ames, Iowa) as a result of natural sowing. There were practically two spring rains after the *Gymnosporangium* was sufficiently advanced to take advantage of moist weather, namely, on April 22 and 23, amounting to 1.26 inches of rain-fall, and June 12 and 13, amounting to 1.59 inches, with only .86 inch distributed among seven showers between the above dates. The sowing following the April rains matured the crops in fifty-eight days. Such a remarkable season rendered it easy to test the length of time required for the growth of the *Rœstelia*, as well as illustrated the fact of successive crops, the number of which would be determined by the number of rains and periods of dry weather during the weeks when inoculation was possible. It is also a matter of observation that the inoculation of the cedar tree for a

new crop of the *Gymnosporangium* in midsummer is dependent upon the character of the weather. A dry summer is not conducive to an abundant "seeding," while August showers favor the parasite.

V.—RŒSTELIA ON APPLES.

The Rœstelia associated with the large conspicuous annual *Gymnosporangium* (*G. macropus*) above described is *R. pirata* (Fig. 1) as given by Mr. Thaxter.

This was first described by Schweinitz as *Æcidium piratum* growing upon *Pirus coronaria*. It is recorded also upon the juneberry and various sorts of cultivated apples. There has been a great deal of confusion in this *Rœstelia*, due to a variety of forms which it probably assumes. Dr. Farlow and Mr. Thaxter, both of whom have given much attention to this subject, are not convinced as to the exact relationship of the various forms of *Rœstelia*, especially the ones associated with *G. macropus*. It does not become me, therefore, to attempt the clearing away of doubts, which can only be done by a long series of cultures of all the species and their forms, both with the teleutospores upon the *Pomeæ* and the *Rœstelia* spores upon the *Cupressineæ*. Volume VII, part 2, of Saccardo's Sylloge Fungorum, just at hand, does not throw as much light upon American species of *Gymnosporangia* as might be desired. The author, Dr. J. B. De Toni, gives but eight species, and only one (*G. clavariæforme*) with its *Rœstelia* upon *Pirus malus* (cultivated apples) and for *G. macropus* mentions only *Pirus coronaria* (wild crab) as the host of its æcidial form. It may be said in passing that *G. Ellisii* is *Phragmidium Ellisii*, Körn, but its relationship to *Rœstelia tranformans* of the genus *Pirus* is fully recognized. It is, however, not the province of this paper, prepared as it is for the popular reader, to enter into a more extended consideration of the genetic relationship than a treatment of the remedial measures will warrant.

Characteristics of the Rœstelia.—The following description is written from the specimens which were obtained by cultivating the spores of undoubted *Gymnosporangium macropus* upon leaves of the common wild crab (*Pirus coronaria*). The first appearances of the *Rœstelia* is a thickened orange patch upon the infested leaf, soon bearing minute dark points upon the upper side (Plate XI, Fig. 1). These spermogonia are followed shortly by the æcidia upon the under side, which are usually in a circle from a quarter to a third of an inch across. The wall of the cup when fully ripe is ashy white, delicate, and splits to the base into numerous slender threads which turn outward and downward (revolute) and touch the base of the peridium (Plate XII, Fig. 1). The cells composing the peridium are 13 to 16 by 100 to 110 μ, and much thickened with transverse striæ upon the inner or concave side. The spores are brown, almost chocolate colored, smooth, somewhat polygonal, and 26 to 33 μ in diameter. In the cultures the stem is often infested with the fungus, and the branch is frequently distorted.

The ease with which the wild crab can be inoculated with the *G. macropus* is remarkable, and not the less striking has been the entire absence of the rust from all kinds of cultivated apple. In the midst of the otherwise full measure of doubt as to the *Rœstelia* of the apple there comes this result of close observation for the past three years. In view of this and other facts of a like nature it seems to me that

too much of the injury to orchards from rusts has been ascribed to *G. macropus*, which is a conspicuous wide-spread species, more easily detected by the general observer than any of the other species having *Rœstelia* growing upon the cultivated apple. The repeated failures of the sown sporidia to produce *Rœstelia* upon any variety of cultivated apples at Ames, Iowa, while at the same time and under similar conditions there has been no failure to obtain abundance of the rust upon the wild crab, furnish ground for this doubt in the prevailing belief. The relation between the two forms is so manifest that cedar and crab-apple trees which stand within ten rods of each other are both very badly infested and have been for years, while cultivated apple trees no farther distant from the same cedars have uniformly failed to develop the *Rœstelia*. There are no doubt great differences of susceptibility among cultivated sorts, and it is possible that in this vicinity only the varieties which are proof against the rust are to be found. However, the college nursery is not more than thirty rods from some infested cedars, and in such nursery rows a large assortment of apples, mostly Russian, however, are grown in great numbers. None of the *Cupressineæ* grow native near the college, and the *G. macropus*, as far as close inspection can determine, is the only species in the vicinity. In other portions of the country where the cultivated apples are badly infested it may be that the rust is due to one or more of the other species of *Gymnosporangium*. For example, the *R. lacerata*, which is a form of *G. clavariæforme* of the common juniper, is well understood as growing upon cultivated apple. Also *R. aurantiaca*, the form so conspicuous upon the quince fruit, is a pest in the apple orchard, and has as its teleutosporic condition the *G. clavipes* which infests both the red and the common cedar.

VI.—TREATMENT

As a remedial measure it passes without further comment that it is well to destroy all specimens of the red cedar or savin (*Juniperus Virginiana*). In that way the only known host of *G. macropus* would be destroyed and one of the two for *G. clavipes*. The remaining hosts for Gymnosporangia, which, in their Rœstelia form, infest the apple are the white cedar (*Cupressus thyoides*) and common juniper (*Juniperus communis*). The range of these two species is very wide and the former often attains to a large size and produces a durable quality of timber of great service in many ways. The common juniper, growing, as it does, only as a low shrub, could be disposed of without seriously marring the beauty of the landscape or doing injury to any American industry. The red cedar is a prominent ornamental shrub or small tree, and there would be some objection to its eradication. If it must remain it would not tax the patience of a conscientious fruit-grower to go over the plants in late autumn and gather the "apples" before they have arrived at that state when they can be infectious to the apple trees. The galls are annual, not deeply seated, and can be quickly removed without doing violence to the tree. It would be better to do this gathering in late autumn or even in winter than to delay until spring, with all of its hurry caused by the pressing work incident to the opening season. The wild crabs or any stray trees of the cultivated sorts must not be overlooked, for they, and particularly the crab, furnish

a means of continual propagation of the pest, especially if the *Rœstelia* is perennial. It is fortunate for the orchardist that the uprooting of all such wild apples is no serious sacrifice, and for other reasons, as a rule, barring a single week of a profusion of fine sweet-scented blooms in spring, these plants may well be classified among perennial weeds of large growth. It is, perhaps, unnecessary to treat here of any remedies that may be applied similar to those that have proved efficient in checking the inroads of the mildews upon the grape, unless it be to spray the fruit trees at just the time when the sporidia are apt to come in contact with the foliage. No set time can be laid down for this, as it will depend upon the locality and season. Inoculation takes place shortly after a rain in middle spring and the period would be long or short depending upon the prevailing weather at the time. As the labor of making the required applications, to say nothing of the expense for apparatus and chemicals, would be much more than the gathering of the cedar apples in the case of *G. macropus*, it goes without further saying that remedial measures other than the knife are here neither urged nor recommended. It would be less easy to cut out the affected portion of the white cedar bearing *G. Ellisii* and of the common juniper with its *G. clavipes*, which would eradicate the quince rust as well, and *G. clavariœforme*, but this is the shortest way. As for the latter host it may as well be pruned level with the ground, but for the white cedar the case is less easily met. However, it may be that *Gymnosporangium Ellisii* is one which is the least injurious of all.

Very likely some varieties of cultivated apples are more susceptible to the rust than others, but as the observations upon this point are meager and fragmentary it is not safe to draw any general conclusions from them. Varieties like Fallawater and Red June are mentioned as subject to the rust, while the Early Harvest and Red Astrachan are not badly attacked. If it is true that *G. macropus* is the cause of the larger part of the rust of cultivated apples the experiments in Iowa would indicate that the varieties from Russia and elsewhere which are being tested for hardiness in the severe and treacherous climate of the State were proof against the rust caused by *G. macropus*.

In treating of the rust of the grain it was shown that there were three distinct stages through which the fungus passed from the teleutospore to the final state again. In short, there was the æcidio, the uredo, and the teleuto conditions. In such a parasite it is evident that the difficulties of eradication are multiplied. In the apple rusts there are only two known forms, namely, the æcidio and the teleuto conditions. With the wheat rust one remedy consists in destroying the barberry; the rest of the work of eradication needs to be, from the nature of the fungus, largely preventive. To this end the seed wheat is soaked in chemicals, the leading one of which is cupric sulphate (sulphate of copper, blue vitrol, blue stone, etc.), for the purpose of destroying the adhering rust germs. All the rusts are deeply seated parasites which do not show themselves upon the surface until it is too late to apply an effective remedy. Therefore but little can be hoped for from direct action of remedies upon the affected parts. With our apple rust both the hosts are trees, and in most cases the fungi are perennial; it therefore follows that the preventive measures used in connection with seed grain do not apply.

VII.—BIBLIOGRAPHY.

Burrill, T. J.: Bulletin Ill. St. Lab. of Nat. Hist., Vol. II, pp. 209 and 239; 1885.
Danger, L.: Unkranker und Pflanzlecher Schmarotzer; p. 134; 1887.
Ellis, J. B.: Notes on Gymnosporangia and Rœstelia; Am. Nat.; p. 1281; 1883.
Farlow, W. G.: The Gymnosporangia or Cedar apples of the United States; Ann. Mem. Boston Soc. Nat. Hist.; p. 38; 2 plates; 1880.
——— Notes on Gymnosporangia; Tor. Bull. VIII; p. 88; 1881.
——— Notes on some species of Gymnosporangia and Chrysomyxa of the United States; Proc. Am. Acad. Arts and Sc.; XII; p. 311; 1885.
——— Development of the Gymnosporangia of the United States; Bot. Gaz.; XI; p. 234; 1886.
Frank, Dr. A. B.: Die Krankheiten des Pflanzen; pp. 475–480; 1880.
Halsted, B. D.: Relations between Cedar apples and leaf-rust upon Crab apple; Bulletin Ia. Ag. Col.; p. 59, 1886, and p. 90, 1888.
Peck, C. H.: Twenty-fifth Report New York State Museum; p. 91; 1871.
Saccardo & De Toni: Sylloge Fungorum; Vol. VII, Part II, p. 737; 1888.
Sanford, E.: Microscopical Anatomy of the common Cedar apple; Am. Bot., Vol. I, No. III; p. 263; with plate; 1888.
Scribner, F. L.: Fungous Diseases of Plants; Dept. of Ag.; Rept.; p. 79; 1885.
Seymour, A. B.: Orchard Rusts; Trans. Am. Hort. Soc.; IV; p. 152; Fig. 14; 1886.
Sorauer, Dr. P.: Die Obstbaumkrankheiten; pp. 105–112; 1882.
Thaxter, R.: On certain cultures of Gymnosporangia, with notes on their Rœstelia; Am. Acad. of Arts and Sc.; p. 259; 1887.
Von Thümen, F.: Die Bekampfung der Pilzkrankheiten unser Culturgewachse; p. 76; 1886.
Winter, Dr. G.: Die durch Pilze verursachten Krankheiten der Culturgewachse; pp. 107–111; 1878.
——— Die Pilze, Rabenhorst Kryptogamen Flora, Part I; pp. 232–234; 1884.

10.—SEPTOSPORIUM ON GRAPE LEAVES.*

(Plate XIII.)

I.—GENERAL OBSERVATIONS.

During the summer of 1887 Professors Scribner and Viala collected a fungus on the wild grape vines (*Vitis Californica*) at Orange, Cal., which in external appearance closely resembles *Septosporium Fuckelii*, known only on foreign vines.

The following is an extract from Professor Scribner's note-book:

"Found on leaves of wild vines, *Septosporium Fuckelii*. Leaves on some vines destroyed by this fungus. On the upper surface, the first appearance of the disease is comparable to that of the Downy Mildew. Spots on under side nearly black and round, not irregular, as with *Peronospora*."†

The spots referred to grow larger and coalesce, so that occasionally nearly the entire leaf surface becomes black below and brown above. It has not been reported on the cultivated grape.

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*SEPTOSPORIUM HETEROSPORUM, ELLIS & GALLOWAY.—On living leaves of *Vitis Californica*, near Orange, Cal. Collected by Prof. F. L. Scribner, October, 1887.

Spots scattered and more or less confluent, indefinitely limited, rusty brown above, one-half to 1 centimeter in diameter, smoky black below or appearing gray on account of the tomentum of the leaf.

Hyphæ hypophyllous, issuing in fascicles from the stomata of the leaf and bearing at their apices the very variable conidia which are at first oblong-cylindrical, 2 to 3 septate, 20 to 40 by 5 to 7 μ, like the conidia of a *Cercospora*. These conidia soon become constricted at the septa and each of the three or four cells become uniseptate. The three primary septa gradually become deeper until the conidia finally separate into three or four separate uniseptate segments of a short elliptical or nearly spherical shape, about 12 μ in diameter, with the epispore distinctly roughened. We have compared this with specimens of *Septosporium Fuckelii*, Thüm., as represented De Thümen's Mycotheca Universalis, 671, and with specimens collected in Algeria by Professor Viala. The California specimens differ in their much shorter hyphæ and very different conidia, which are much constricted at the septa.

†Botanical Gazette, January, 1888.

II.—BOTANICAL CHARACTERS.

The black appearance of the lower surface is caused by the fruiting portion of the fungus. The sporophores are in tufts which project from the stomata, and are borne upon a knot of mycelium just under the epidermis. They are composed of short, septate, dark colored hyphæ, rounded at the apex and tapering toward the base, each bearing a chain of conidia.

The spores are dark colored, numerous, and usually several septate. At first they are smooth, not constricted at the septa, and generally not more than four celled, but as they grow older the surface becomes rough, the number of cells increase, they become much constricted at the septa, and occasionally longitudinal septa make their appearance (Fig. 4). New septa also appear in the older spores. The time of the formation of the septa may be inferred by their thickness and the degree of constriction around them. The different cells continually become more and more spherical, so that the older cells are nearly perfect spheres and have a tendency to fall apart. The chains of spores assume very different shapes according to their age and environment. The spores examined were from dried specimens and the phenomena of growth were not observed, but, judging from the forms assumed, the process of development would be as indicated. The appearance of roughness of the spore-walls, especially in immature specimens, *appears* to be due to a granular arrangement of the contents, but if these are shrunken by some reagent the irregularities do not disappear and are plainly seen to exist in the walls.

These fruiting tufts may be entirely independent, but they are also found in connection with a spermogonial form (Figs. 5, 6). In this case they spring from the side or apex of the capsule, passing through a stoma as before. The spermogonia may also be independent (Fig. 6), not connected with any conidial form, and having the ostiola situated beneath the stomata. In these independent capsules the cells around the ostiolum frequently project a little, giving the impression, when looking down upon them, that the conidiophores have broken off at the base; and this idea is strengthened by finding septa at the base of nearly every fruiting hypha. Frequently also the stroma at the base of the conidiophores is much enlarged, as if a spermogonium were in process of formation.

The spermogonium is a thin-walled, yellowish brown capsule, its outer cells frequently extending into mycelium threads. It is lined with a layer of colorless, flask-shaped cells, on which the spermatia are borne; these seem to be produced in chains, which fall apart, leaving the spores septate. The spermatia (Fig. 7) are bacillus-like and partake of the Brownian movement. They measure 4 to 7 by $1\frac{1}{2}$ to 2 μ, are usually straight, sometimes slightly curved, and usually larger at the ends than in the center.

The differences between this form and *Septosporium Fuckelii* may be seen by comparing Figs. 1 and 2 with 3 and 4. The conidiophores and spores of *Fuckelii* are more slender and the conidiophores are longer; those of the new form are clavate, but those of *Fuckelii* are not. It would be well to say in this connection that in Viala's *Les Maladies de la Vigne* the conidiophores of *Fuckelii* are drawn clavate. The drawing in this report was made from a camera-lucida sketch of material collected by Professor Viala in Algeria, and is true as regards this material. There is probably a considerable vari-

ation between different specimens. There is, however, much difference in the spores. The mature spores of *Fuckelii* are almost identical with the young spores of the American species, but the older spores of the latter are broader, constricted more or less deeply at the septa, and the surface shows peculiar markings, due to irregularities which are not present in *Fuckelii*. The illustrations of the spores show typical forms of both species, but the tufts of conidiophores both contain rather fewer than the average number of hyphæ.

Viala gives the length of the spores as from 30 to 60 μ. Those we have measured vary from 5 to 10 by 20 to 55 μ, and those of the American species measure 5 to 12 by 13 to 50 μ. The mere figures do not indicate much variation between the species. The specific differences consist rather in the shape and general appearance of the spores and conidiophores, and in the fact that one species is found in connection with spermogonia and the other is not.

11.—Leaf-spot Disease of the Maple.

Phyllosticta acericola, C. & E.

(Plates XIV, XV.)

I.—GENERAL OBSERVATIONS, HISTORY, ETC.

In many parts of the West, maple trees, especially those belonging to the silver-leaved species, *Acer dasycarpum*, are frequently attacked by a parasitic fungus which greatly injures their appearance and lessens their value.

The fungus attacks the leaves exclusively, destroying the chlorophyll (green coloring matter) wherever it gains a foothold, and consequently interfering with assimilation. This may occur to such an extent as to decrease the growth of the wood, causing the trees to become weak and more or less stunted. In addition, the foliage becomes very unsightly (Plate XIV), so that in sections where the disease is especially prevalent people prefer to plant shade trees not subject to the attacks of such disfiguring maladies, and in consequence the sale of maples by nurserymen is considerably diminished.

The disease is especially severe where a large number of trees are grown together, as in nurseries and groves. Isolated trees are rarely seriously attacked.

The beauty and grace of the maple and its easy cultivation have long made it one of the most popular and widely used of all our shade trees. A disease, therefore, which injures it in any way demands our attention.

Hosts.—The fungus attacks the species *dasycarpum*, *rubrum*, and *Pennsylvanicum.** In the West *Acer dasycarpum* suffers especially from its attacks; but in the District of Columbia it is *A. rubrum* that seems to be most subject to the disease, and *A. dasycarpum* is comparatively exempt.

Geographical distribution.—So far as known the fungus is restricted to this continent, but it seems to be very wide-spread through the United States. It is reported from New York, New England, New Jersey, Illinois, Kansas, and other States. It has also been found

* As a matter of convenience the different species of maple will be referred to here under their botanical names, as follows: *Acer dasycarpum*, White or Silver maple; *Acer rubrum*, Red maple; *Acer Pennsylvanicum*, Striped maple.

abundantly in the vicinity of Washington, D. C. In the nurseries of Missouri Agricultural College it caused considerable injury to the young trees three or four years ago.

History.—The fungus causing the disease seems to have been first collected in New England on *Acer rubrum* by a Mr. Sprague, and described from his species in 1874 by Messrs. Berkeley and Curtis as *Sphæropsis minima.** In 1879 Peck reports finding it on the same host in Greenbush, N. Y.† In 1880 Cooke and Ellis described a fungus found on "Maple leaves" in New Jersey which they called *Phyllosticta acericola.*‡ In his Sylloge Fungorum, Saccardo publishes these species as independent, but changes *Sphæropsis minima*, B. & C. to *Phoma minima*, Sacc.§ In the Journal of Mycology for 1886‖ Dr. George Martin gives *Sphæropsis minima* as a synonym of *Phyllosticta acericola*, and finally Farlow in his Host Index¶ has published *Phyllosticta acericola*, C. & E., *Sphæropsis minima*, B. & C., and *Phoma minima*, Sacc., as synonyms.

If the law of priority is to hold in the nomenclature of fungi, this fungus probably ought to be known as *Phyllosticta minima*, (B. & C.), C. & E., but since it was published independently by Cooke & Ellis as *P. acericola* and this name afterward adopted by Dr. Martin it is the one that will be used in this paper.

II.—EXTERNAL CHARACTERS.

It makes its appearance upon the leaves about the middle of May, in the form of small, blackish, more or less circular spots, which rapidly increase in size. As they enlarge their shape becomes more and more irregular, their color meantime changing from black to different shades of brown. On *Acer dasycarpum* (Plate XIV) the color of the spot becomes almost a dirty white in the center, surrounded by a black-brown border. On *A. rubrum* the center is reddish brown and the border dark or purplish. The external appearance on the two species is so different as to give the impression to the casual observer of two different fungi. The texture of the spots is also different. In *A. dasycarpum* the diseased tissues are very much more brittle and less coherent than the healthy ones, often showing a disposition to break away from the green portions of the leaf. In *A. rubrum* the affected parts are much firmer, although still more brittle than the healthy portions of the leaf. They, however, do not have the thin, fragile appearance possessed by the spots on *A. dasycarpum*. The difference both in the color and texture of the spots on the two species can probably be accounted for by the difference in color and texture of the healthy leaves. *Acer rubrum* possesses a darker, firmer leaf, the tissues of which would break down much less easily than those of *A. dasycarpum*.

When the spots have attained their full size they vary from 10 to 14 millimeters in diameter, are irregular in outline, and often run together, forming a large irregular patch. In the worst cases the

* *Sphæropsis minima*, B. & C.—Maculis pallide brunneis; perithecii minutis tectis, sporis breviter obovatis. On leaves of *Acer rubrum*. New England, Sprague No. 5314. Forming little sub-orbicular brownish spots; perithecia sub-cuticular minute, spores shortly obovate, 4 μ long. Grevillea, Vol. III, p. 2.

† 30th Rep. N. Y. State Museum, pp. 31 and 77.

‡ Grevillea, Vol. VIII, p. 11.

§ Vol. III, p. 116.

‖ Page 13.

¶ Part I, p. 19.

greater part of the leaf surface becomes occupied by these brown or grayish white patches, and the leaf finally shrivels and dies. The young leaves are attacked as soon as they appear, so that the falling off of the old ones does not free the plant from the attacks of the parasite.

III.—BOTANICAL CHARACTERS.

At any time during the summer or autumn, small black dots, scattered over the lighter portions of the diseased spot, may easily be seen with the naked eye (Plate XIV). Under the microscope these prove to be thin-walled, hollow bodies (Plate XV, Fig. 1), containing the spores or reproductive organs of the fungus. These conceptacles, otherwise known as the pycnidia, are somewhat flask-shaped, have dark-colored walls one or two cells thick, and are provided with an opening or ostiolum for the discharge of the spores. They are also lined with colorless tissue upon which the basidia or spore-bearing stalks are borne.

The thickness of the pycnidia walls and of the lining tissue varies in different hosts, the walls are more distinct, and the layer of colorless tissue thicker in *A. rubrum* than in *A. dasycarpum.*

The spores are colorless, granular bodies 8 to 9μ long by 5 to 6μ in diameter, and usually contain one or more rather large sized vacuoles. They are nearly oval and often somewhat angular in shape, this being caused by the pressure of the spores against each other before they escape from the conceptacle.

The spores are produced in the following manner: The colorless lining tissue gives rise to multitudes of small, cylindrical, club shaped bodies which stand at right angles to the wall of the pycnidium; the free ends of these swell up, and are finally cut off from the supporting portion by a septum. The upper portion has then become the spore and the lower part the basidium, or stalk; the latter is from 10 to 12μ in length and about 4μ in diameter, and usually tapers a little towards the spore. The spore finally breaks off from the stalk and passes out through the ostiolum. These mature spores are capable of reproducing the fungus. If kept for a time in a drop of water they will germinate by sending out a slender filament (Plate XV, Fig. 2), which soon develops into a mycelium. If, as occurs in nature, these spores fall on the leaves of the maple and are there wet by the rain or dew the same thing will happen, but in this case the germinating filament bores into the leaf and the mycelium developing within the leaf tissues feeds upon the plant juices which are required for the sustenance of the plant itself, and interferes with the assimilating power of the leaves.

The mycelium or vegetative part of the fungus is found exclusively between the cells. No haustoria could be determined, but in some cases the cells were so firmly united to the mycelium filaments that they could not be separated by repeated jarring under the cover-glass, even when the specimens had been so macerated that the cells of the host fell apart readily. In the specimens examined the mycelium in *Acer rubrum* (Plate XV, Fig. 3 *a*) was considerably coarser than in *Acer dasycarpum* (Plate XV, Fig. 3 *b*, *c*), but in other respects it is the same. It is branched, septate, and filled with granular protoplasm in both cases. As has been stated, this is the first portion of the fungus to develop between the cells of the host, but it soon forms condensed masses here and there just beneath the upper surface of the leaf. These increase in size and finally rupture the

epidermis, producing the black dots or pycnidia already described. The process of differentiation of the pycnidium and its contents has never been completely followed out.

During winter the fungus lives in the tissue of the decaying leaves, and the stylospores retain the power of germination until the new leaves have come out the following spring. Last spring (1888) stylospores were found in abundance, and germinated as late as the middle of April.

Some leaves that had been left on the ground over winter were examined the following summer, and some of the conceptacles on the diseased spots were found to contain what seemed to be immature asci. These conceptacles or perithecia closely resemble the pycnidia in all respects, save as to their contents, and in the specimens examined these were somewhat indistinct, but the main part of the cavity was plainly filled with bodies closely resembling asci in their shape and arrangement, although no spores could be distinguished. This fact merely increases the probability that the form of the fungus with which we are familiar is only one stage in the life history of an ascosporous species.

IV.—TREATMENT.

No line of treatment has ever been attempted for this disease, and any suggestions in the matter must be purely theoretical, based, however, on a knowledge of the habits of the fungus and the properties of fungicides already tested in similar cases.

Since the fungus lives over winter in the leaves it is obvious that a source of infection will be removed if these are collected in the autumn and burned or buried before they are scattered by the wind. In nurseries where the trees are small it is probable that good results will follow the application of some fungicide which, interposing between the surface of the young leaves and the spores which may fall upon them, will prevent the germination of the latter or destroy their germ-tubes.

Doubtless a solution made by dissolving half an ounce of sulphuret of potassium to the gallon of water will be found as cheap and efficient as any for the application. The solution should be applied to the foliage by means of a force-pump having a nozzle of fine aperture, such as the Riley "Cyclone" or Nixon "Climax," which will distribute the liquid in a fine spray. The first application should be made about the time the leaves are two-thirds grown, repeating the operation every three or four weeks if the season is wet. In nurseries it would be well to select new sites for plantations of young trees as often as possible, as observation has shown that maple trees grown for a number of years in succession upon the same spot suffer more than those in new soil.

V.—BIBLIOGRAPHY.

Berkeley & Curtis: Grevillea; 1874; Vol. III, p. 2. *Sphæropsis minima.*

Cook & Ellis: Grevillea: 1880; Vol. VIII, p. 11. *Phyllosticta acericola.*

Farlow & Seymour: Host Index of the Fungi of the United States; 1888; Part I, pp. 18, 19.

Martin: Journal of Mycology; 1886; p. 13. *Phyllosticta acericola.*

Peck: Thirteenth Report of the New York State Museum; 1879; pp. 51 and 77. *Sphæropsis minima.*

Saccardo: Sylloge Fungorum: 1886; Vol. III, p. 14. *Phyllosticta acericola. Ibid.*, p. 116; *Phoma minima.*

12.—A Disease of the Sycamore.

Glœosporium nervisequum, Sacc.

(Plate XV.)

I.—GENERAL OBSERVATIONS.

For several years the Sycamore trees in the vicinity of Washington have suffered during the spring from the attacks of a parasitic fungus which has been so severe that in many cases the whole tree appeared as if scorched, and sometimes died. The effects of the disease are so conspicuous, and have attracted so much attention, that many will probably be glad to learn the cause of the trouble and history of the disease, even if there is no approved method of removing it.

In 1888 it appeared about the middle of May, and by the last of June many of the largest trees were entirely defoliated. On May 30 the trees along the Virginia side of the Potomac for a considerable distance down the river were carefully examined and every tree, large and small, was found to be badly diseased. On the smaller trees the leaves were all affected alike, but on the large ones only the branches over the lower half showed any signs of the malady. Trees thus affected presented a very peculiar appearance; in fact we have often seen trees, under which large brush-heaps had been burned, having their foliage in exactly the same condition, *i. e.*, the lower half brown and withered, the upper half fresh and green.

Trees in the city were also affected, but not so seriously as those in the country. A row of Sycamores along the Boundary, between Tenth and Twentieth streets northwest, were quite badly diseased. Here the malady was confined almost entirely to the lower branches, athough the trees were comparatively small, many of them being less than 25 feet high.

Trees near Hyattsville and College Station, Md., were in a number of instances killed outright by the disease, but most of those in or near the city recovered toward the middle of summer, at which time the malady had for the most part disappeared.

Geographical distribution.—It has been observed in Ohio, Kentucky, and Indiana, and we have reliable evidence that it existed in New Jersey (Ellis) and Illinois (Waite). It has been collected in California by Harkness on *Platanus orientalis*,* and Dr. Vasey states that a number of years ago his attention was called to what was probably the same thing while traveling through Kentucky. So far as known the disease does not occur in Missouri, and careful observations during the past season in Mississippi failed to reveal its presence there (Tracy). It is present in Europe, where it has been found in Germany, Italy, and France.

Hosts.—It occurs on *Platanus racemosa*, *orientalis*, and *occidentalis*, and Fuckel reports it upon *Quercus*. Hitherto it has been reported on the leaves only, but we have found it on the growing, unlignified stems and on the petioles.

History.—It was first named *Hymenula plantani* by Leveille, and the description was published in the Annales des Sci. Nat. for 1848.†

*Journal of Mycology, Vol. I, p. 110.

† *Hymenula Platani* nov. sp. Receptaculis gregariis amphigenis innatis dein erumpentibus minutis carnosulis, orbicularibus vel ovatis pulvinatis, flavo-rubescentibus macula exarida insidentibus; sporis ovatis, vel curvatis continuis utrinque obtusis.

Hab. in Gallia meridonali. Legit cl. Castagne ad folia *Plantani orientalis*.

Fuckel changed it to *Fusarium nervisequum*, but Saccardo has transferred it to the genus Glœosporium, and this has been adopted by Ellis in the Journal of Mycology.

II.—BOTANICAL CHARACTERS.*

The effects of the fungus are most evident on the young leaves at the ends of the branches. The leaves seem most liable to attack at about the time they have attained their full growth. When the disease attacks the leaves themselves a brown patch of variable size makes its appearance, either where the veins fork at the base of the leaf, or somewhere along the course of the nerves. When a vein is attacked the flow of sap is checked, and the parts of the leaf that are supplied with sap by the vein in question will wither and die. Sometimes, however, there is a small diseased spot along a vein with no other perceptible effect of the fungus. The spots are dry and brittle, and a close examination will reveal small, dark dots on both surfaces, especially along the veins on the lower side.

Very often, however, a leaf or all the leaves on the end of a growing branch suddenly wilt, and the closest examination will not show any traces of the fungus. In this case it can invariably be found on the petiole or on the branch itself, where its action in breaking down the tissues has cut off the supply of sap from the leaf or leaves beyond.

The dark colored dots already referred to are small pustules containing the fruit of the fungus. On the leaf (Plate XV, Fig. 5) this usually forms just beneath the lower epidermis. Within the pustules and resting on the outer cells of the mesophyll is a thin hymenium, formed of colorless, thin-walled pseudo-parenchyma. This bears a layer of straight, cylindrical, pointed, colorless basidia set close together, which are septate at the base and bear spores on their free ends. The spores (Fig. 6) are one-celled, ovate, and colorless. The pressure of the basidia and spores ruptures the epidermis, after which it usually turns back entirely, exposing the layer of basidia and spores.

On the living bark of the preceding year there are often small protuberances resembling lenticels, but more elevated; sections through these reveal two conditions of a fungus. In the Botanische Zeitung for 1886 Franz von Tavel has published a very full description of this fungus under the name of *Discella platani*. In the earlier stages it is merely a cone-shaped mass of pseudo-parenchyma, apparently formed by the lateral union of parallel filaments. After a time basidia and spores are formed in the center of the mass, and finally the entire cone disappears, leaving an ordinary fruit pustule, strikingly resembling those of the *Glœosporium* on the leaf, except that it is larger and the stroma at the base of the basidia thicker (Fig. 4). There is an abundant colorless, septate, branching mycelium which completely breaks down the tissue. Von Tavel made repeated cultures of the spores of this fungus with a view to ascertaining whether it had any genetic connection with the *Glœosporium* on the leaves, but the results were negative. The first impression upon seeing the mature form of the *Discella* is very strong that it is the

*The microscopic work represented in this paper was completed with one exception, before Von Tavel's paper came to the knowledge of the author; the one exception is in regard to the intermediate stages between the mature and immature form of *Discella platani*.

same thing found on the leaf, but beyond the morphological evidence there is no proof, save that diseased stems and leaves do often come from the branches upon which we find the *Discella*. It is possible that the fungus may have two forms of development, one for the leaf and another for the bark, and that the formation of the pseudo-parenchymatous mass at first is necessary in order to rupture the cork layer and the epidermis of the bark and allow the escape of the spores. Von Tavel considers this as the pycnidium form of some fungus.

In spring many of the younger branches on the diseased trees are dead and spotted with small, dark colored pustules. These pustules are made up of several capsules containing spermatia like spores. They disappear by the latter part of June, leaving an empty, dark-colored cavity in the bark.

Whether or not this is what Von Tavel calls *Cytispora platani* we have no means of deciding. The perithecia form was not found, and we have no specimens for comparison.

In addition to these forms there is another, which sometimes occurs upon the ends and buds of dead branches. It consists of very large, irregular pycnidia, containing large spores borne upon prominent basidia. The spores are colorless and one-celled when young, and dark yellow and often two-celled when mature. This can hardly be Tavel's *Fenestella platani*.

Whether or not there is any genetic connection between these forms and the *Glœosporium* is an open question. Von Tavel's carefully conducted experiments are without definite result save in the line of the *Cytispora*, and in this case the evidence goes to prove that it is quite independent of the *Glœosporium*, having, on the contrary, an *Acrostolagmus* as its conidial form.

It hardly seems reasonable that the life history of the *Glœosporium* is confined to the form on the leaves, especially when we consider that this stage only lasts about two months of the year. From the abundance of other fungi on the branches at the time when the *Glœosporium* makes its appearance it seems quite probable that one or more of them may be found to have some genetic connection with it.

III.—TREATMENT.

The size of the trees makes the use of fungicides very difficult; and the fact that the trees are not important from an economic point of view renders any attempt in this direction undesirable. It is always best to destroy any leaves that fall from the effects of the fungus, as in this way multitudes of spores are destroyed. In case of shade trees it will not be a very difficult task to remove all dead branches before the leaves come out in the spring, in order to avoid the possibility of the fungus originating from spores that might be produced on them.

IV.—BIBLIOGRAPHY.

Ellis: Journal of Mycology; Vol. I; p. 110.
Frank: *Hymenula plantani;* Die Krankheiten der Pflanzen; p. 613.
Fuckel: *Fusarium nervisequum;* Symb. Myc.; p. 369.
Grevillea: Vol. XIV; p. 124.
Léveille: *Hymenula plantani;* Ann. des Sci. Nat.; 1848; p. 128.
Saccardo: Syll. Fung.; Vol. III; p. 711.
————: Mich.; p. 381.
Sorauer: Pflanzenkrankheiten, second edition; Vol. II; p. 424.
Von Tavel: Botanische Zeitung; 1886; p. 825.

13.—The Leaf Rust of Cottonwoods.

Melampsora populina Lév.

(Plate XVI.)

I.—GENERAL OBSERVATIONS.

The leaves of poplars, especially the Cottonwood (*Populus monilifera*), are frequently covered during summer and autumn with an orange rust. The affected trees shed most of their leaves during summer long before the regular time, and frequently attract attention by their defoliated appearance.

This rust is not very conspicuous and might easily pass unobserved, but upon taking one of the fallen leaves in hand it is seen to be covered with small yellow pustules from which at maturity a fine yellow powder is discharged over the surface of the leaf. Later, during autumn, the leaves become covered with small, reddish-brown specks, not powdery in their nature, but hard and crust-like, scarcely raised above the surface.

The yellow powder and dark-colored specks are masses of spores or reproductive bodies of a parasitic fungus, a minute plant belonging to the family *Uredineæ*, or rusts.

The most remarkable fact concerning the *Uredineæ* is the polymorphism or alternation of forms which most of the species undergo. As a rule they pass through three different stages, producing each time a different kind of spore. These conditions are quite unlike, and older botanists thought they belonged to different genera. In the spring the cluster-cup condition develops. In this stage the spores, usually light yellow in color, are produced in little cups which burst through the epidermis of the leaf forming what is known as the æcidio stage. During the summer the second stage or uredoform appears usually on a different host plant from the first. Its spores are commonly thin walled, covered with minute spines, and borne on very fragile stalks.

The mature reproductive bodies called the teleutospores develop at the close of the season, usually on the same host plant as the uredospores, and frequently on the same spots. The teleutospores are thick walled, dark colored, and filled with dense protoplasm. While the uredospores must germinate soon after maturity or else not at all, the teleutospores usually refuse to grow until the next season. The former are for the purpose of rapidly spreading the fungus during the growing season; the latter are capable of surviving the winter and serve the purpose of the seeds of higher plants.

II—EFFECT ON HOST.

The mycelial threads of the fungus penetrate but a short distance laterally. Indeed, only a few cells each way from the small yellow sorus are reached by the parasite. A minute yellow spot extending through the leaf and visible on the opposite side surrounds each of the uredo sori. This is the only direct effect of the uredo form on the leaf tissue. The formation of the teleutospores draws more heavily on the vitality of the leaf, and when their sori occur thickly the leaf tissue is killed and the green coloring matter decomposed so that an irregular brown patch is formed or frequently the whole leaf discolored.

The most important effect which this fungus has on its host is that of causing the leaves to fall prematurely. The shedding of leaves by trees is a natural process; they are cut off by the formation of a plane of cork cells through the place of separation. Some trees are peculiarly sensitive and drop their leaves at the slightest disturbance, as, for instance, improper nutrition. The Cottonwood is one of this sort, and the disturbance which the fungus creates in the leaves is sufficient to cause them to fall. We have observed a row of Cottonwoods planted for shade almost completely defoliated from this cause by the middle of August.

III.—HOSTS AND GEOGRAPHICAL DISTRIBUTION.

Melampsora populina is common in the eastern and central portions of the United States on the Cottonwood (*Populus monilifera*), and occurs occasionally on the American Aspen (*P. tremuloides*), the angled Cottonwood (*P. angulata*), the large-toothed Aspen (*P. grandidentata*), the Balsam Poplar (*P. balsamifera*), and the Balm of Gilead (*P. balsamifera* var. *candicans*). It has not yet been reported from the far West or the Pacific coast, but will probably be found when looked for.

In the Old World it grows on *Populus nigra* and several other species of Poplar, and is found in all the countries of Europe and in Asiatic Siberia. It probably occurs entirely around the world in the North Temperate Zone.

IV.—BOTANICAL CHARACTERS.

If a small quantity of the orange-colored dust from one of the uredo sori be transferred to a slide and examined under a high power of the microscope it is found to consist of minute rounded or obovate, light-colored, thin-walled bodies which are covered with minute tubercles. These are the uredospores (Fig. 3); and in thin sections it is seen that they originate from a mass of mycelium beneath the epidermis. As the growth of the parasite proceeds, the latter is forced upward, finally ruptured (Fig. 1), and remains for some time as a partial covering for the sorus. Among the uredospores in the pustule are borne club-shaped paraphyses (Fig. 3 *c*). Both spores and paraphyses arise from a layer of fungous tissue, the *hymenium*.

The uredospores are apparently sessile; in fact, Burrill,* in defining the genus, says, "uredospores sessile upon the hymenium." Winter,† however, says that they are borne on basidia. The fact is they are provided with pedicels which so closely resemble the cells of the hymenium that they may easily be taken for the latter. Moreover, they project slightly, if at all, above the general level of the hymenium and separate very easily from their attachment when mature. By careful manipulation, however, the spores may be isolated with the pedicels attached; it is then seen that they differ from the ordinary pedicellate uredo forms only in the length of their stalks (Fig. 3).

Turning to the mature form of the fungus, a section through one of the crust-like, dark-colored teleuto sori (Fig. 2) shows an altogether different appearance. The teleutospores (Fig. 4) are not un-

* Parasitic Fungi of Ill., p. 211.
† Die Pilze, p. 237.

like the palisade cells of the leaf in size and shape, but are distinguished from them by their brownish tint and granular protoplasmic contents. They are oblong-cylindrical in shape with a smooth, thin wall. They are closely packed into a single layer with the longer diameter at right angles to the stratum, in the manner of paving-blocks, and grow more or less prismatic in shape from mutual pressure. They are inclined to be slightly wedge-shaped, with the larger end up, and are more slender, longer, and regular in the large sori than in the small ones. A stratum of these spores develops in small spots beneath the epidermis, and in a section cells of the latter may be seen much flattened and distorted (Fig. 2). In a few cases small, crowded masses of teleutospores were found farther inside the leaf-tissue, not forming a crust under the epidermis. These spores are more nearly round than the others. The teleutospores are not borne on stalks, as is commonly the case among the rusts, but arise directly from a cushion of cellular fungous tissue (Fig. 2).

The mycelium is very meager, consisting of mere prolongations of the hymenium among the adjacent host cells; in no case were slender mycelial threads of any considerable length seen. The mycelial branches are always short, septate, and irregular. In a few cases the host cells lying close under the center of the sorus were so broken down that they seemed to be penetrated by the mycelium; but even here it was not satisfactorily made out on account of the difficulty of distinguishing between the discolored protoplasm which clung to the sides of the cells and the fungus mycelium. However, the common occurrence of the mycelium was between the cells, which seemed to be little distorted by its action and not seriously disturbed in function. In most instances the host cells under the uredo sori retain their green chlorophyll, even though the cell may be completely surrounded by the parasite.

V.—TREATMENT.

From the nature of the trees attacked, usually large, it would be difficult to apply any remedy. Moreover, the parasites of the group to which this belongs are among those least affected by fungicides. The fungus grows wholly inside the host plant, and does not break through the epidermis so as to be easily seen until it is in full fruit.

From the usually small value attached to Cottonwoods, it would not be considered profitable to spray them, even though success were certain. By thoroughly raking up the leaves and burning them in the fall millions of the spores would be destroyed. The more thoroughly this is done the less will be the chances for infection the next year. This is probably the only attention which this disease can be expected to receive.

VI.—BIBLIOGRAPHY.

Arthur, J. C.: Preliminary list of Iowa Uredineæ; p. 163.

———: Report on Botanical work in Minnesota for the year 1886; p. 29.

Berkeley, M. J.: Outlines of British Fungology; p. 334.

Burrill: Parasitic Fungi of Illinois: Uredineæ; p. 214.

Cooke, M. C.: Microscopic Fungi; p. 221. Hand-Book of British Fungi; p. 523.

De Toni, J. B.: Saccardo, Sylloge Fungorum; VII; p. 590.

Langlois, A. B.: Catalogue Provisoire de Plantes de la Basse-Louisiane; p. 31.

Trelease, William: Parasitic Fungi of Wisconsin; p. 29.

14.—REPORT ON PEACH YELLOWS.

By ERWIN F. SMITH, Special Agent.

I.—TREES AFFECTED.

Yellows is primarily a disease of peaches and nectarines, but it has also been observed in almonds and apricots.

II.—WHEN AND WHERE DISCOVERED.

It was first written upon in 1806, having been observed in the immediate vicinity of Philadelphia prior to that date, perhaps as early as 1791, or even 1760. The peach itself has been successfully cultivated in this country since about 1630. It was first planted in the Chesapeake region, and not long after on the shores of the Delaware.

III.—FORMER SEVERITY.

Within a few years after it was first described, yellows appeared in all the Atlantic Coast States north of Virginia, and caused great loss, destroying in a few decades hundreds of orchards and thousands of trees in Delaware, New Jersey, Pennsylvania, New York, and Connecticut, and putting an entire stop to peach-growing in many sections.

IV.—PRESENT DISTRIBUTION.

In recent years this disease has appeared in Ontario, Michigan, Illinois, and Georgia, and seems not to have completely disappeared from any of its former strongholds. So far as known, yellows now extends from Maine to Georgia, and westward to Lake Michigan and the Mississippi River. It has not been reported from California or from any State west of the Mississippi, and its existence has not been definitely established in any of the Gulf States, although it undoubtedly occurs in some of them. This disease is also unknown abroad, or at least has not been described from any other part of the world. It should be looked for in the Mediterranean region, in China, in New Zealand, in Argentine Confederation, and especially on our own West coast, in California.

V.—PRESENT SEVERITY.

In recent years the disease has been no less destructive than formerly. Thousands of young and thrifty trees have been destroyed by it, and peach-growing has been abandoned in several parts of the country where formerly there were many large and profitable orchards, *e. g.*, at Saint Joseph, in Berrien County, Mich.; at Middletown, in New Castle County, Del.; near Niagara River in New York and Ontario; and along the bay shore in Harford County, Md.

The disease now prevails disastrously on the Chesapeake and Delaware Peninsula, in the most productive peach region on the continent. On this peninsula it is confined principally to the counties of Cecil and Kent in Maryland, and of New Castle and Kent in Delaware, but is extending into other regions formerly free. The disease is also now prevalent in Cumberland, Morris, and Hunterdon Counties in New Jersey, and in other parts of the United States. It is everywhere the same obscure, destructive malady.

VI.—SYMPTOMS.

The earliest unmistakable symptom of yellows is the premature ripening of the fruit. Diseased trees ripen their fruit, in whole or in part, from a few days to several weeks in advance of the proper time. Often the peaches on one or two limbs only will be diseased, all the rest ripening in a normal manner. In such cases the premature peaches are full-grown, ripe, and high-colored, when those on the rest of the tree are green and but half grown.

These peaches, no matter what their natural color, are more or less red and purple-spotted on the skin and splashed and streaked within. Sometimes the normally white or yellow flesh is very beautifully mottled, or almost entirely crimson; again, there is only a trace of abnormal color. The flavor of premature peaches varies considerably, but they are usually insipid and sometimes bitter. They are not fit to eat but are sometimes put upon the market in large quantities, especially early in the season and in years of scarcity. Such fruit can readily be distinguished from healthy by its high color and spotted appearance and should be rejected.

The next symptom, which generally appears the same season but is sometimes delayed until the next, is the appearance of diseased, dwarfed growths upon the trunk or limbs. These growths bear diminutive leaves, which are pale green, yellowish, reddish, or white, as if etiolated. They often show a marked tendency to repeated branching, sometimes as many as four sets of branches being developed in a few months. These growths may arise either from obscure buds on the trunk and main limbs or from ordinary winter buds. They may appear at any time during the season from spring until late autumn. Often the winter buds push in October or November, after the foliage has fallen, or even in August and September, while it is still green and vigorous.

When attacked the tree is very often in a vigorous, healthy looking condition, and sometimes during the whole of the first season there is no sign of disease beyond the appearance of a few premature peaches, the foliage being full-grown and dark green and the shoots in no way dwarfed or sickly. As already intimated, the disease usually appears first in one limb or on one side of the tree, but sometimes in all parts of the tree at once or on opposite sides. No matter to how slight an extent the tree is first diseased, it never recovers, but becomes entirely diseased in course of two seasons, or, at most, three.

The limbs first attacked are badly diseased the second year, their entire growth, shoots, and foliage, being much dwarfed and of a sickly green, tinged with yellow or reddish brown. In course of two or three seasons the entire growth of the tree assumes this appearance, and is then a sufficient warrant for the common name, such trees, especially when massed in orchards, being distinguishable at some distance by their yellow or reddish-brown appearance, which is in marked contrast with the beautiful dark green of healthy foliage.

Trees not infrequently die outright the second year of attack, but ordinarily they languish for a number of years, dying gradually from the extremities downward. Often such trees are barren after the first year, or they may bear another crop of premature peaches, which are, however, of small size and very inferior flavor.

VII.—DISEASES MISTAKEN FOR YELLOWS.

Other diseases of the peach have been mistaken for this.

Trees may bear premature fruit when severely injured by the peach-tree borer, *Ægeria exitiosa*, Say. The cause of this prematuring is easily discoverable. It never occurs until the tree is nearly girdled at the earth surface, and ready to die. The foliage of such trees is always yellowish, *i. e.*, when fruit is premature by borers it is never borne on healthy, vigorous-looking trees. Moreover, the peaches are not red-spotted, and the trees do not put forth the diseased shoots which are symptomatic of "yellows."

Root aphides (*Aphis chrysanthema*, Koch. ?) cause peach trees to assume a sickly yellow appearance. Often they are also much dwarfed, and not infrequently they die; but never, so far as I have observed, do they bear premature peaches or the characteristic shoots. On the roots of such trees, even in late autumn or winter, this aphis may often be found in large numbers. I have also seen it upon the branches in August and in January, but have never found the winged form.

The "root-knot," due to a parasitic worm, *Anguillula* sp., has made its appearance in Georgia, Alabama, and Florida, and causes the foliage of peach trees to turn a sickly yellow. If the attack is severe the younger branches die back, and sometimes the whole tree perishes, but without any symptoms characteristic of "yellows."

A soil deficient in food elements, *e. g.*, a barren sand, may also cause a yellow and stunted appearance, with premature aging and decay, but such trees plainly indicate starvation, and are in marked contrast to those attacked by yellows.

VIII.—CAUSE OF YELLOWS.

The cause of this disease is still unknown, but there is reason to believe it will be discovered at no distant day.

It has been attributed to severe freezing in winter, but this can hardly be a sufficient cause, because it occurs where the winters are not severe, and is absent in places where peach trees have suffered severely from the cold.

It has been attributed to excessive rain-fall, but it has been absent from one locality and present in another, when both suffered from excessive precipitation. Moreover, in localities wet in 1887 and dry in 1888 the disease seemed to prevail without reference to the changed condition, *i. e.*, as many healthy trees were attacked in 1888 as in 1887.

It has been attributed to impoverishment of the soil, especially to a deficiency of lime, potash, and phosphoric acid; but it now occurs on fertile soil, both virgin and highly improved, in as destructive a form as was ever observed in the most impoverished district, and is now absent from certain poor, sandy regions, deficient in the elements necessary to the growth of vegetation.

Yellows has also been attributed to parasites. I am inclined to think no insect has to do with the disease unless it be the root aphis before mentioned, and there seems to be enough evidence to rule this out. None of the higher fungi sometimes found in the parts above ground appear to stand in any causal relation to yellows. An unusual number of rootlets are dead in trees affected by this disease, and an evanescent cobweb mycelium observed on these rootlets

may be the cause, but is quite as likely to be a consequence, *i. e.*, a pure saprophyte. This possible cause and the root aphis are still under consideration.

Peach-growers have believed very generally that one great danger lay in the careless selection of pits for nursery stock, whereby many from premature peaches were included. The results of my attempt to grow infected trees from diseased pits were all negative. In 1887 over 3,100 pits from premature, red-spotted peaches were collected and carefully planted, but only fifteen trees resulted, all of which are now healthy. The peaches were taken from young and old trees, all vigorous and in the first stage of the disease, but in very many cases the pit contained no kernel or only an imperfect one—dry, watery, or black. Past experiments corroborate my own and indicate that the pits of very few premature peaches will grow.

Upon the theory that yellows is due to some "germ" which enters through the blossoms, it would seem as if one ought to be able to cut out the disease before it spreads through the entire tree. This theory is as old as the time of William Prince, and has been popular from the fact that the disease sometimes appears the first season in a single peach or in the peaches of one twig only, the rest of the tree appearing to be perfectly healthy. In 1887 and again in 1888, an attempt was made to remove the disease from slightly affected trees by prompt and severe excisions. From one-third to two-thirds of each tree was removed for the sake of getting rid of a few infected limbs. In most cases a large part of that which was removed and all of that which remained was perfectly healthy, if normal and vigorous fruit, foliage, and shoots be any indication of health. The results of the experiments in 1887 were entirely concordant and satisfactory. Twenty-four trees were under observation and in no case was the disease removed or its progress checked by the excisions. The possibility of re-infection was not excluded, but the probability is slight from the fact that in 1888 only 10 per cent. of the remaining healthy trees had become diseased, while every one, *i. e.*, 100 per cent., of the excised trees showed the disease. If these twenty-four trees were all re-infected it would seem that a larger number of the surrounding trees should have become diseased. Moreover, these twenty-four trees were all so badly diseased as to seem to preclude the idea of re-infection. They were nearly as bad as any of the other trees attacked in 1887. The result of the excisions made in 1888 is not yet known.

The result of some inoculations made in 1887 is also gratifying, and seems to put the communicable nature of "yellows" beyond reasonable doubt.

In August about one thousand healthy seedling trees were inoculate with buds from diseased trees as in ordinary budding. Owing to the interruption of this investigation in the spring of 1888, several lots of these trees were shipped without proper care and suffered much in transit so as to somewhat confuse results; but two lots, each of about two hundred trees, were uninjured, and to these the present discussion will be confined.

One of these lots, inoculated with buds apparently healthy but taken from a tree on which were some limbs in the first stage of the disease, was sent to a locality free from yellows, and up to the last of June showed no trace of the disease. Unfortunately these trees were not examined in the autumn, and their present condition is not known.

The other lot, inoculated with buds from the characteristic shoots of trees in the first year of the disease, was left in the nursery where budded. The result of these inoculations is very conclusive. The trees were examined in August, 1888, and again in November. Most of the inserted buds "caught," but very few of them grew. Some grew into shoots which seem to be healthy; others grew into diseased shoots, as was to be expected. The point of most interest is that about 40 per cent. of the previously healthy stocks contracted the disease from the inserted buds and sent out feeble wiry growths, often at a distance of some inches from the inserted buds. The evidence of this infection of the stocks could be seen in July, was clear in August, and still plainer in November, when nearly all of the winter buds on some of the stock shoots were just pushing under the influence of the disease. Even as early as August, 26 per cent. of the infected stocks were dead; and others, then languishing, were dead in November.

Of the entire lot of two hundred trees only thirty-nine appeared to be entirely healthy in November. The following table shows the condition of these trees in the autumn of 1888:

Result of experiment undertaken to determine whether yellows can be transmitted by budding. Trees inoculated in Maryland August 12, 1887. Buds selected from diseased shoots on young and thrifty trees of Crawford's Late.

Condition.	August examination.		November examination.	
	Trees.	Per cent.	Trees.	Per cent.
Healthy	47	23	39	19
Doubtful	21	11	24	12
Diseased	81	40	67	33
Dead	53	26	72	36
Total	202	100	202	100

From this table it is apparent that the condition of the trees was considerably worse in November than in August. It will be observed also that even in August a relatively large per cent. were dead. Earlier in the season many of these same trees put out feeble shoots from the inserted bud or the stock, but these grew only from one-half an inch to 3 inches and then died. A June examination would undoubtedly have shown a much larger number of healthy trees and fewer dead ones. The trees marked *Healthy*, as well as a majority of those marked *Doubtful* and *Diseased*, showed a green, thrifty-looking top, and at a distance gave no indication of disease. As a rule, however, their growth was not as robust as that of trees in the adjoining rows.

For comparison, trees were examined in the same row and in the row on each side to the number of five hundred and fifty and found healthy. These trees are of the same age and stock, and were budded at the same time, but from healthy trees. The contrast was very striking, and the comparison *left no doubt whatever* that in this case the disease was due entirely to the insertion of the unhealthy buds.

These trees are still under observation, and it is to be hoped that the other lot can also be examined and reported on during the coming season.

Additional experiments and laboratory investigations are under way and will be reported upon later.

IX.—REMEDIES.

All advertised "cures" are humbugs. No remedy is yet known. Nothing can be recommended with confidence, but it is very generally believed, especially in Michigan and Ontario, that the disease may be held in check by the prompt removal and burning of all diseased trees. To be effective this must be done promptly and completely upon the first appearance of the disease.

As an additional precaution it would be best to procure trees from localities not now suffering from yellows.

X.—ON REPLANTING, ETC.

The question is often asked, Will it pay to replant when orchards have been destroyed by yellows? That depends upon the nearness to market, the extent to which the disease is present, etc. In Michigan, where diseased peach trees are usually dug out promptly, peach orchards are on the increase, and the loss of trees per annum, it is said, rarely exceeds 5 per cent., and is usually much less. Even in New Jersey, where no restrictive measures are in force, and where growers expect to lose their trees after two or three crops, the business is still considered profitable, and many trees are planted each year to take the place of those diseased. Many growers hesitate to set trees in the place of those removed on account of yellows, but the results of trials in Michigan during the last ten years show that it can be done without danger. Trees thus reset are in no special danger. They do not contract yellows sooner than others in the same orchard. Peach-growing is so profitable, especially on the Chesapeake and Delaware peninsula, that this experiment is certainly worth trying upon an extended scale.

For an explanation of the text, see accompanying maps and illustrations, and for additional information consult a special report on Peach Yellows, recently published by this Section.

15.—ADDITIONAL NOTES ON CELERY-LEAF BLIGHT.

Cercospora apii, Fries.

In the Annual Report for 1886 this fungus was figured and described, and a partial account of the injury occasioned by it was furnished. More extended observations on the subject have shown that the damage to celery plants resulting from its attacks is greater than was at first supposed, owing to the fact that the peculiar yellowish appearance of the foliage which characterizes the disease is often attributed to "sun scald," "red spider," etc.

Our first experience with this malady was in 1881, at which time it made its appearance about the last of July in a number of beds, containing in all about 10,000 plants. The plants were grown from seed sown in a green-house in March, and were for the most part of the varieties known as "Boston Market" and "Golden Heart." The last of April they were pricked out in the open ground, and by the middle of June, being strong and vigorous, they were lifted for the last time and transplanted into rich, highly manured soil. They made a good start and grew rapidly for a few weeks, but about the last of July the plants in one bed began to show signs of disease and three weeks later nearly all the plants were entirely destroyed.

For a time endeavors were made to check the disease by destroying the yellow leaves as fast as they appeared, and by the application of solutions of hyposulphite of soda, sulphuret of potassium, etc. Despite all our efforts, however, the disease progressed rapidly, and the plants were finally abandoned to the fungus and weeds. The latter grew luxuriantly in the beds where the soil was unusually moist, and here the celery plants, which were well shaded, soon recovered from the effects of the fungus and remained healthy throughout the summer.

The next season the celery beds were made beneath several large locust trees which effectually protected the plants from the sun, and during the whole season not a plant thus protected was destroyed by blight. Our only explanation of the foregoing facts is, that celery being a native of a cool, moist climate it has not the constitutional vigor to withstand the hot, parching sun of our summers, consequently when exposed to the latter certain conditions which favor the development of the fungus and retard the growth of the celery are brought about, and as a result the latter succumbs to the attacks of the parasite. So far as our observations have extended the disease occasions the greatest injury in sections where the summers are long, hot, and dry. In regions where the soil throughout the hot months is cool and moist, and the air is also in a constantly humid condition, the disease is unknown. Just such conditions as the foregoing are to be met with in the vicinity of Kalamazoo, Mich., where the finest celery in the country is grown.

Where it is not practicable to shade plants by natural means, such as has already been referred to, artificial shades in the shape of screens made of coarse sacking or laths will be found fully as effectual. For several reasons lath screens are preferable to those made of cloth; they are cheap and easily made by nailing the laths at each end to two narrow boards 10 feet in length. The laths are usually placed about 1 inch apart, thus allowing plenty of air to reach the plants, at the same time effectually shading them. Such screens when finished are 4 feet wide and 10 feet in length; they may be supported by posts driven down on either side of the bed, the height of the former of course depending upon the size of the plants. As the plants increase in size the screens may easily be raised. At the approach of cool weather, which usually comes on in September, the screens may be discarded entirely, as the fungus at this season looses its activity. It remains alive, however, in the old leaves during the winter and following spring, but so far as we have been able to discover it does not change its form. Conidia were found on fragments of old leaves late in the spring of 1888, and these germinated readily when sown in water. A knowledge of this fact shows the importance of destroying the old diseased leaves in the autumn, as each small fragment of the latter harbors thousands of the reproductive bodies of the fungus. What is probably only a form of the parasite under consideration often attacks the common parsnip, a plant closely related to the celery, producing a diseased condition of the foliage similar to the celery-leaf blight. The fungus in this case differs slightly from that which occurs upon celery, but whether the two forms are really identical has not, so far as we know, been proved.

B. T. GALLOWAY,
Chief of Section.

Hon. NORMAN J. COLMAN,
Commissioner.

EXPLANATION OF PLATES.

PLATE I.

POTATO ROT—PHYTOPHTHORA INFESTANS, DBY.

FIG. 1. Potato leaf, showing brown spots caused by the fungus.
FIG. 2. Section through a diseased potato, showing discoloration in the outer portions, due to the presence of the *Phytophthora* in the tissues.

PLATE II.

POTATO ROT—PHYTOPHTHORA INFESTANS, DBY.

FIG. 1. Section through a diseased leaf, showing the mycelium in the tissues and two external spore-bearing hyphæ projecting through a stoma.
FIG. 2. Conidia and conidiophores more enlarged. The epidermis and stoma are shown in the surface view. (F. L. Scribner, del.)
FIG. 3. A series of drawings, representing successive stages in the development of a conidium: *a*, end of conidiophore slightly swollen; *b*, *c*, successive stages in the growth of the conidium; *d*, the conidiophore has pushed on, leaving the conidium already formed attached to an enlargement below the point, and has begun to form another conidium on the end; *e*, the first-formed conidium has fallen from the enlargement of the conidiophore at *g*, and the second conidium formed is in turn left behind by the growing conidiophore, which is forming a third conidium at the end.
FIG. 4. Mycelium in the tissue of a potato tuber. (F. L. S., del.)
FIG. 5. Series of figures representing the germination of a conidium: *a*, mature conidium; *b*, same, after remaining some time in water, five vacuoles have made their appearance; *c*, the contents are segmented into five distinct parts, each of which is provided with a vacuole; *d*, the exospore has ruptured and the zoospores are in the act of escaping; *e*, free zoospore; *f*, same a little later, the vacuoles have become smaller; *g*, same, still later, the cilia are gone and the zoospore has come to rest; *h*, beginning of germination; *i*, *k*, *l*, successive stages in the growth of the germ tube or first mycelium filament; *m*, entrançe of germ tube into the leaf through a stoma.
FIG. 6. Section of leaf, showing the penetration of a germ tube into the epidermis through the cell wall.

PLATE III.

BLACK-ROT OF TOMATO—MACROSPORIUM SOLANI, RAV.

FIGS. 1 and 2. Diseased fruit in different stages of decay, showing the black appearance and sinking in of the decayed portions. (R. Cowing, fecit.)
FIG. 3. Tuft of conidiophores, showing characteristic protuberances on which spores have been borne. (E. A. Southworth, del.)
FIG. 4. End of branched conidiophore with spore attached to one of the branches. (E. A. S., del.)
FIG. 5. Spores. (E. A. S., del.)
FIG. 6. Germinating spores. (E. A. S., del.)
FIG. 7. Tuft of conidiophores without the protuberances shown in Fig. 3: *a*, mycelium. (E. A. S., del.)

PLATE IV.

TOMATO DISEASES—FUSARIUM SOLANI, MART., AND CLADOSPORIUM FULVUM, CKE.

FIG. 1. Ends of conidiophores bearing macroconidia: *a a*, immature; and *b*, mature macroconidia. (R. C., del.)
FIG. 2. Branch of a hypha that has run over the surface sending out upright conidiophores; the macroconidia on the latter are immature. (R. C., del.)

FIG. 3. Portion of branched conidiophores from one of the fruiting tufts that break through the epidermis: *b*, conidiophore; *a a*, immature macroconidia. (R. C., del.)
FIG. 4. Mature macroconidia. (R. C., del.)
FIG. 5. Germinating macroconidia: *a*, only a few hours in water, one of the segments has swollen; *b*, later stage; *c*, spore forming a microconidium at the end. (R. C., del.)
FIG. 6. Microconidia: *a a*, immature forms; *b*, mature, showing rough exospore.
FIG. 7. Germinating microconidium. (R. Prestele, del.)
FIG. 8. Mycelium between the cells of the tomato. (R. C., del.)
FIG. 9. Tuft of conidiophores of *Cladosporium fulvum*. (E. A. S., del.)
FIG. 10. Spores and ends of conidia-bearing branches: *a*, *b*, *c* are probably ends of fruiting branches capable of breaking up into spores; *d d*, germinating spores. (E. A. S., del.)
FIG. 11. Peculiar and characteristic forms of conidiophores, showing method of branching and bearing spores. (E. A. S. del.)

PLATE V.

BROWN-ROT OF CHERRY—MONILIA FRUCTIGENA, PERS.

FIG. 1. Upper side of a diseased leaf, showing the irregular brown spots made by the fungus. (R. C., fecit.)
FIG. 2. Lower side of a diseased leaf. (R. C., fecit.)
FIG. 3. Bunch of cherries, some of which are attacked by the fungus: *a*, cherry which was diseased the year before, and has hung on the tree over winter; *b*, green, healthy cherries; *c c*, diseased cherries with the blossom (*d*) clinging to the fruit. (R. C., fecit.)

PLATE VI.

BROWN-ROT OF CHERRY—MONILIA FRUCTIGENA, PERS.

FIG. 1. Fruiting tuft that has broken through the epidermis—from apple. (E. A. S., del.)
FIG. 2. Mycelium found in dried specimens of diseased apple: *a*, showing passage through cell wall; *b*, coarse hyphæ passing into finer ones. (E. A. S., del.)
FIG. 3. Cell of peach, showing the fine mycelium in the cell. (E. A. S., del.)
FIG. 4. Piece of coarse mycelium from fresh peach; the protoplasm is so full of vacuoles as to give it the appearance of a network. (E. A. S., del.)
FIG. 5. Germinating spores from the same fungus on plum, showing fusion of germ filaments, both uniting the spores themselves and the main filaments proceeding from them. (E. A. S., del.)
FIG. 6. Germinating spores from the fungus on peach, shown in optical section. (E. A. S., del.)
FIG. 7. Spores from peach, showing some in the first stages of germination; at *a* two germ-tubes are approaching preparatory to fusion. (E. A. S., del.)

PLATE VII.

POWDERY MILDEW OF CHERRY—PODOSPHÆRA OXYCANTHA (DC.), DBY.

FIG. 1. Perithecium from the fungus on *Prunus cerasus*, viewed nearly from above, showing the septate appendages. The appendages are usually a little longer than here represented. (M. B. Waite, del.)
FIG. 2. A well developed appendage from a perithecium on *Cratægus tomentosa* (much enlarged). (M. B. W., del.)
FIG. 3. Ascus from a perithecium on *Prunus cerasus*, showing the contained ascospores: *b*, one of the ascospores, showing the granular protoplasmic contents. (M. B. W., del.)
FIG. 4. A portion of the mycelium with conidiophores and rows of conidia (from peach leaves): *a*, conidiophores; *b*, conidia; *c*, four nearly mature conidia, with the upper one about to be detached; *d*, three mature conidia, detached. (E. A. S., del.)

FIG. 5. Section through the epidermis of an infested peach leaf, showing a short piece of the mycelium (*a*) and a haustorium (*b*) extending into an epidermal cell. (E. A. S., del.)

FIG. 6. A pycnidium and portions of the mycelium of *Cicinobolus Cesatii*, DBy., showing the mycelium inside that of the *Podosphæra*. (M. B. W., del.) The spores are seen exuding from the apex of the pycnidium. (Drawings all made from nature by the aid of the camera lucida.)

PLATE VIII.

LEAF BLIGHT AND CRACKING OF THE PEAR—ENTOMOSPORIUM MACULATUM, LÉV.

FIG. 1. End of branch, showing leaves with characteristic spots caused by the fungus. (R. C., fecit.)

FIG. 2. Diseased fruit, showing spots and crack. (R. C., fecit.)

PLATE IX.

LEAF BLIGHT AND CRACKING OF THE PEAR—ENTOMOSPORIUM MACULATUM, LÉV.; LEAF SPOT OF ROSE—CERCOSPORA ROSÆCOLA, PASS.

FIG. 1. Section of leaf through a disease spot, showing a fruit pustule containing spores in different stages of development. (E. A. S., del.)

FIG. 2. Young spores, showing method of development and attachment to the mycelium. (E. A. S., del.)

FIG. 3. Mature spores. (E. A. S., del.)

FIG. 4. Spermogonium form often found on the same leaves with *Entomosporium*, surface view. (E. A. S., del.)

FIG. 5. Section of same. (E. A. S., del.)

FIG. 6. Mature or ascosporous stage of the fungus: *a*, ascus containing the two-celled ascospores; *b*, empty ascus with pore open at the apex through which the spores have escaped; *c*, germinating ascospores; *d*, same, more advanced; *e*, paraphyses. (After Sorauer.)

FIG. 7. Tuft of conidiophores and conidia of *Cercospora rosæcola: a*, spore; *b*, conidiophore. (E. A. S., del.)

FIG. 8. Spores from fungus collected after a spell of wet weather, which probably accounts for the difference between them and the spores in Fig. 7. (E. A. S., del.)

PLATE X.

PLUM POCKETS—TAPHRINA PRUNI (FCKL.), TUL.

FIG. 1. Branch, natural size, showing the appearance of the pockets. (R. C., del.)

FIG. 2. Surface view of the network of mycelium between the epidermal cells and the cuticle.

FIG. 3. Section through the outer surface of the pocket, showing the mycelium in the tissues and between the epidermal cells and the network in section above these. (After Sorauer.)

FIG. 4. Section, showing young asci which have not yet ruptured the cuticle. (E. A. S., del.)

FIG. 5. Section showing asci in different stages, some of them mature and containing spores, the others resemble those of Fig. 4. (E. A. S., del.)

FIG. 6. Asci, more enlarged and separated from the others, showing septum, pedicels, and spores. (E. A. S., del.)

PLATE XI.

APPLE RUST—RŒSTELIA PIRATA, THAX.?

FIG. 1. Apple leaves, showing the æcidium stage: *a*, upper side of leaf; *b*, under side. (R. C., fecit.)

FIG. 2. *Gymnosporangium macropus* or Cedar apple. (R. C., fecit.)

PLATE XII.

APPLE RUST—RŒSTELIA PIRATA, THAX.

FIG. 1. Fragment of leaf, showing the under side with the cluster cups. The peridia are slit and turned back, as is characteristic of this species. (R. C., del.)
FIG. 2. Æcidio spores, showing thin places in the cell wall for the passage of the germ tubes: *a a*, thin places. (Drawing made from specimens that had been soaked in a strong potash solution.) (E. A. S., del.)
FIG. 3. Germinating spores: *a a*, germ tubes. (E. A. S., del.)
FIG. 4. Spores of *Gymnosporangium*. (E. A. S., del.)
FIG. 5. Germinating spore of same: *a a*, sporidia. (After Farlow.)
FIG. 6. Germinating sporidia. (E. A. S., del.)

PLATE XIII.

NEW GRAPE DISEASE—SEPTOSPORIUM HETEROSPORUM, ELLIS AND GALLOWAY.

FIG. 1. Tuft of conodiophores of *Septosporium Fuckelii*. (E. A. S., del.)
FIG. 2. Spores of same. (E. A. S., del.)
FIG. 3. Tuft of conidiophores of *Septosporium heterosporum*. (E. A. S., del.)
FIG. 4. Spores of same. (E. A. S., del.)
FIG. 5. Spermogonium of same, with tuft of conidiophores growing from apex of capsule. (E. A. S., del.)
FIG. 6. Section through a spermogonium, showing the spermatia and manner in which they are borne. (E. A. S., del.)
FIG. 7. Spermatia, much enlarged. (E. A. S., del.)

PLATE XIV.

MAPLE-LEAF BLIGHT—PHYLLOSTICTA ACERICOLA, C. & E.

FIG. —. Showing the spots on both sides. (R. C., fecit.)

PLATE XV.

MAPLE-LEAF BLIGHT—PHYLLOSTICTA ACERICOLA, C. & E.; SYCAMORE DISEASE—GLŒOSPORIUM NERVISEQUUM, SACC.

FIG. 1. Section through pycnidium of *Phyllosticta acericola* on *Acer dasycarpum*. (E. A. S., del.)
FIG. 2. Germinating spores. (E. A. S., del.)
FIG. 3. Mycelium: *a*, in *Acer rubrum*; *b*, in *Acer dasycarpum*. (E. A. S., del.)
FIG. 4. Section through mature pustule of *Discella platani* on bark of *Platanus*. (E. A. S., del.)
FIG. 5. *Glœosporium nervisequum* on leaf. (E. A. S., del.)
FIG. 6. Spores. (E. A. S., del.)

PLATE XVI.

POPLAR LEAF RUST—MELAMPSORA POPULINA, LÉV.

FIG. 1. Section through sorus containing uredospores. (E. A. S., del.)
FIG. 2. Section through sorus containing teleutospores. (M. B. W., del.)
FIG. 3. Uredospores and paraphyses: *a a a*, spores in optical section; *b*, surface view; *c c*, paraphyses; *d*, immature spore. (E. A. S., del.)
FIG. 4. Teleutospores: *a a*, in optical section; *b*, surface view. (M. B. W., del.)

PLATE XVII.

HEALTHY PEACH SHOOT—DELAWARE.

Robust terminal shoot. Taken August 20, 1888, from a healthy tree in orchard of Joseph McDaniel, Dover, Del. Reduced to about one-fifth natural size.

PLATE XVIII.

DISEASED PEACH SHOOTS—DELAWARE.

Shoots from an obscure bud on limb of a tree badly diseased by yellows; such shoots usually remain *entirely* unbranched in healthy trees. Taken September 3, 1887, from orchard E. P. Selmser, Dover, Del. Reduced to about seven twenty-fourths natural size.

PLATE XIX.

HEALTHY AND DISEASED PEACHES—DELAWARE.

Stump the World or Old Mixon peaches, taken August 20, 1888, from orchard of Joseph McDaniel, Dover, Del. Natural size.

No. 1. green and healthy; No. 2, from a neighboring tree, red-spotted and prematurely ripe.

1

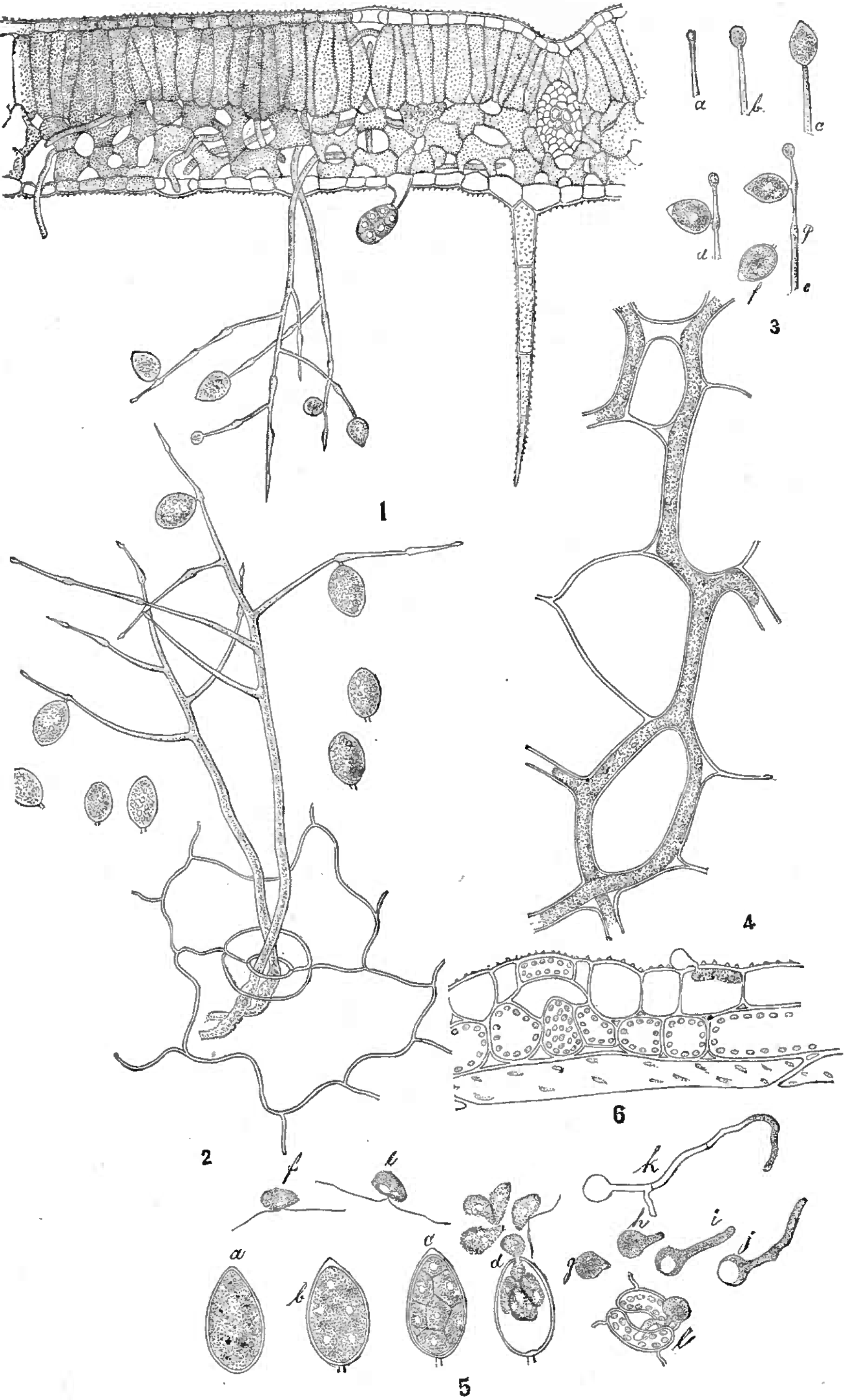
2.

DOWNY MILDEW AND ROT OF POTATO.

Phytophthora infestans, D. By.

THE HATCH LITHO CO N Y

PLATE II.

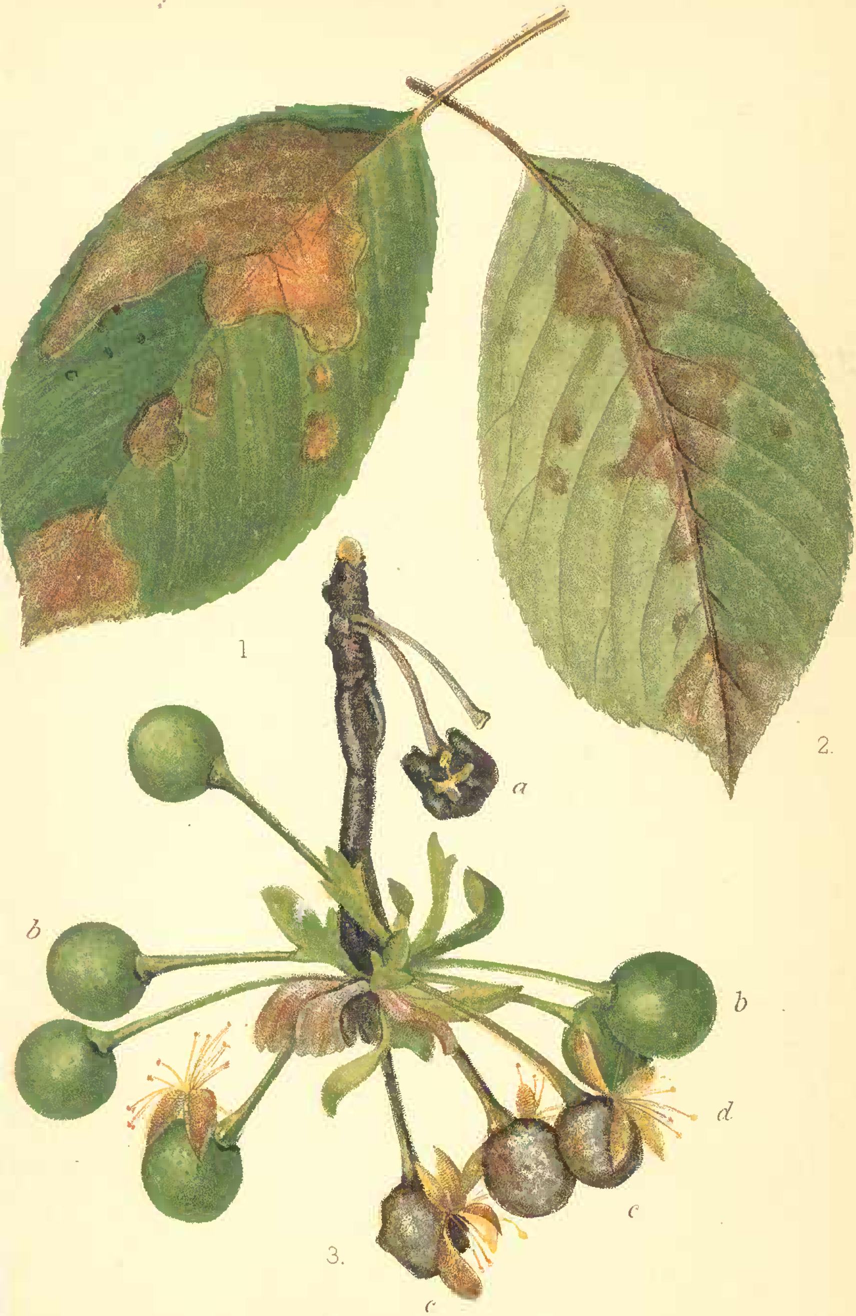


DOWNY MILDEW OR ROT OF POTATO (PHYTOPHTHORA INFESTANS, D BY.).

TOMATO ROT.
Macrosporium Solani

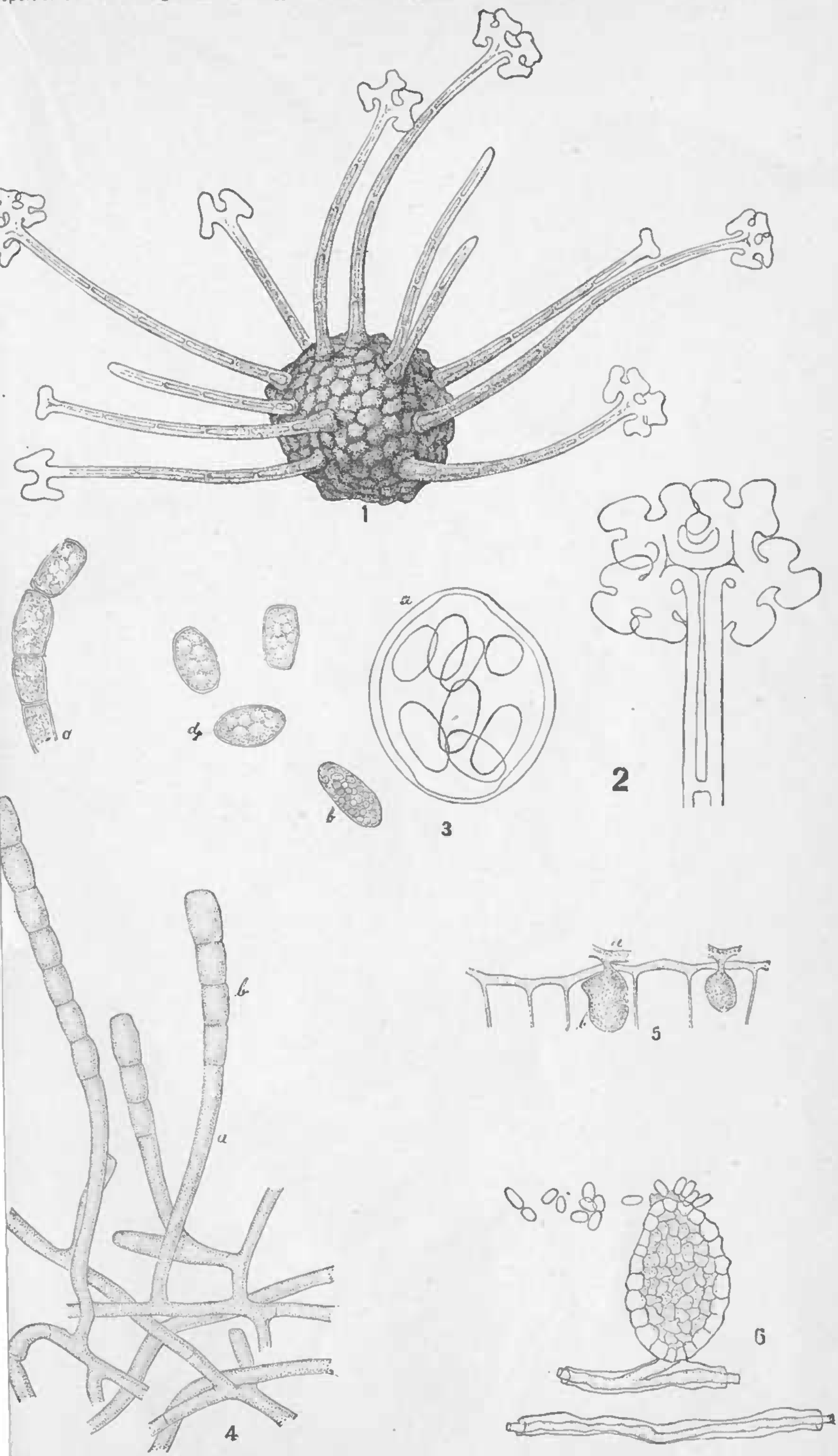
THE HATCH LITHO CO N Y

TOMATO DISEASES (FUSARIUM SOLANI, MART., AND CLADOSPORIUM FULVUM, CKE.).



BROWN ROT OF CHERRY.
Monilia fructigenum Pass.

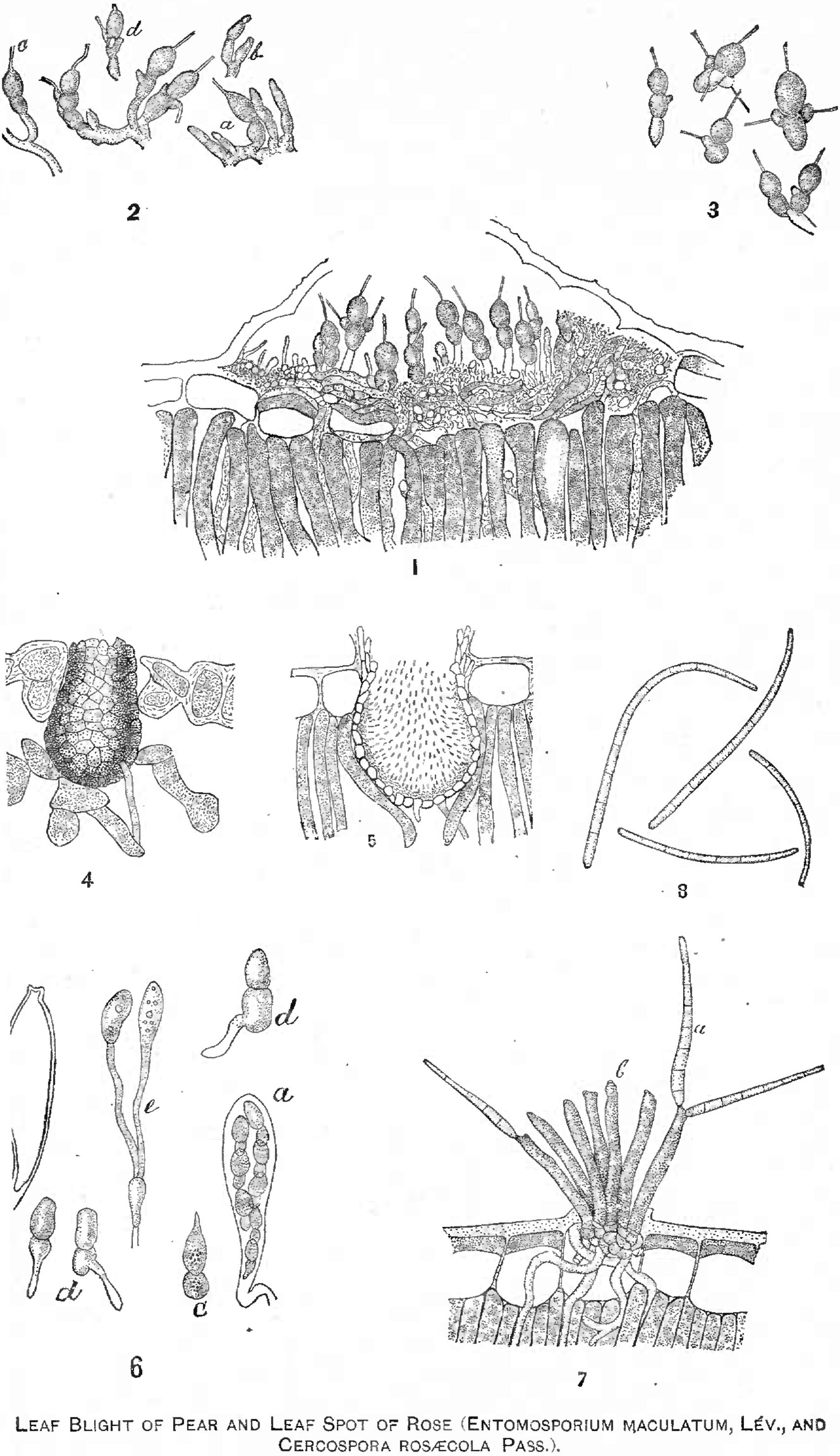
BROWN ROT OF THE CHERRY (MONILIA FRUCTIGENA, PERS.).



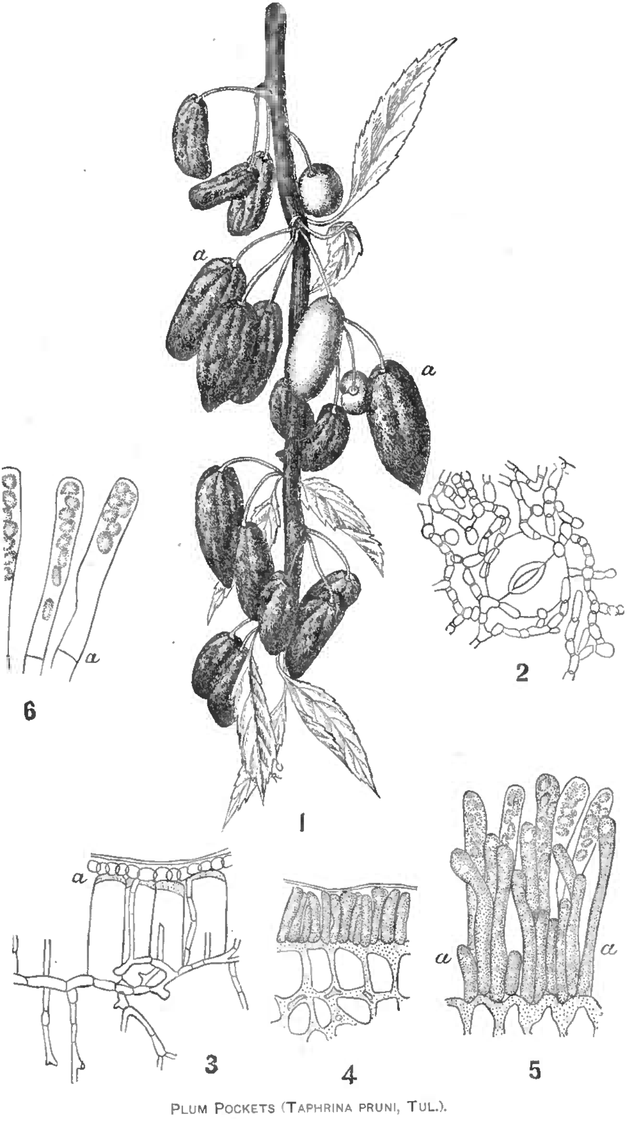
POWDERY MILDEW OF CHERRY (PODOSPHÆRA OXYCANTHA. D BY.).

LEAF BLIGHT AND CRACKING OF THE PEAR
Entomosporium maculatum Lev

THE HATCH LITHO N. Y.



LEAF BLIGHT OF PEAR AND LEAF SPOT OF ROSE (ENTOMOSPORIUM MACULATUM, LÉV., AND CERCOSPORA ROSÆCOLA PASS.).

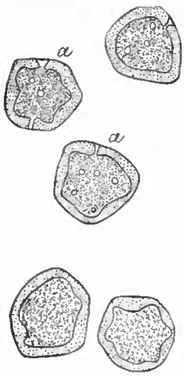


PLUM POCKETS (TAPHRINA PRUNI, TUL.).

APPLE LEAF RUST AND CEDAR APPLE.

Roëstelia pyrata, Thax. and Gymnosporangium macropus, Link.

THE HATCH LITHO CO. N. Y.



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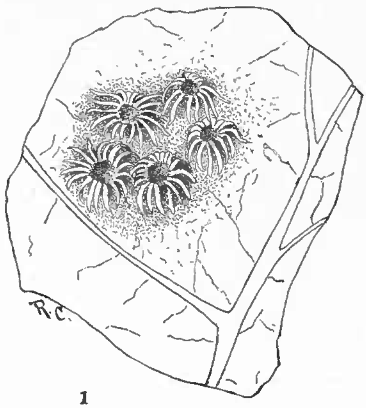

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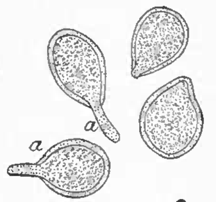

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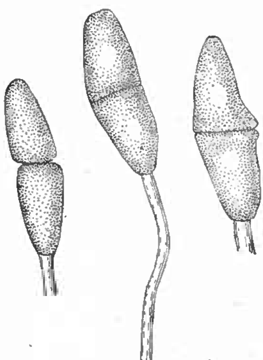

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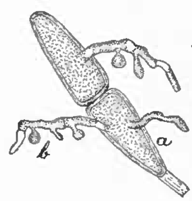

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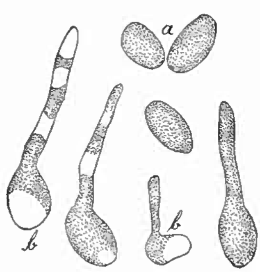

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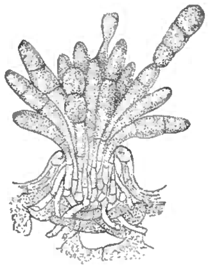
APPLE RUST (RŒSTELIA FYRATA, THAX., AND GYMNOSPORANGIUM MACROPUS, LINK).



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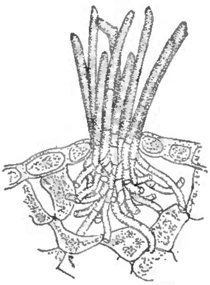

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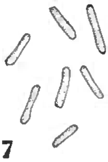

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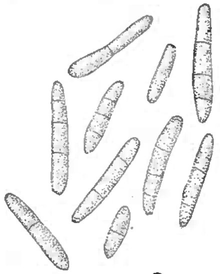

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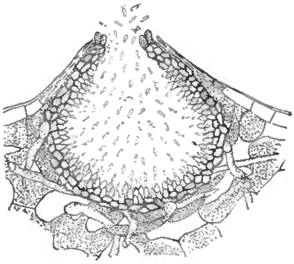

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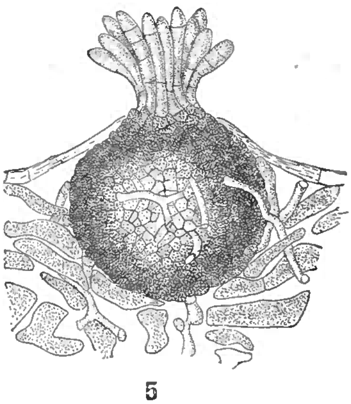


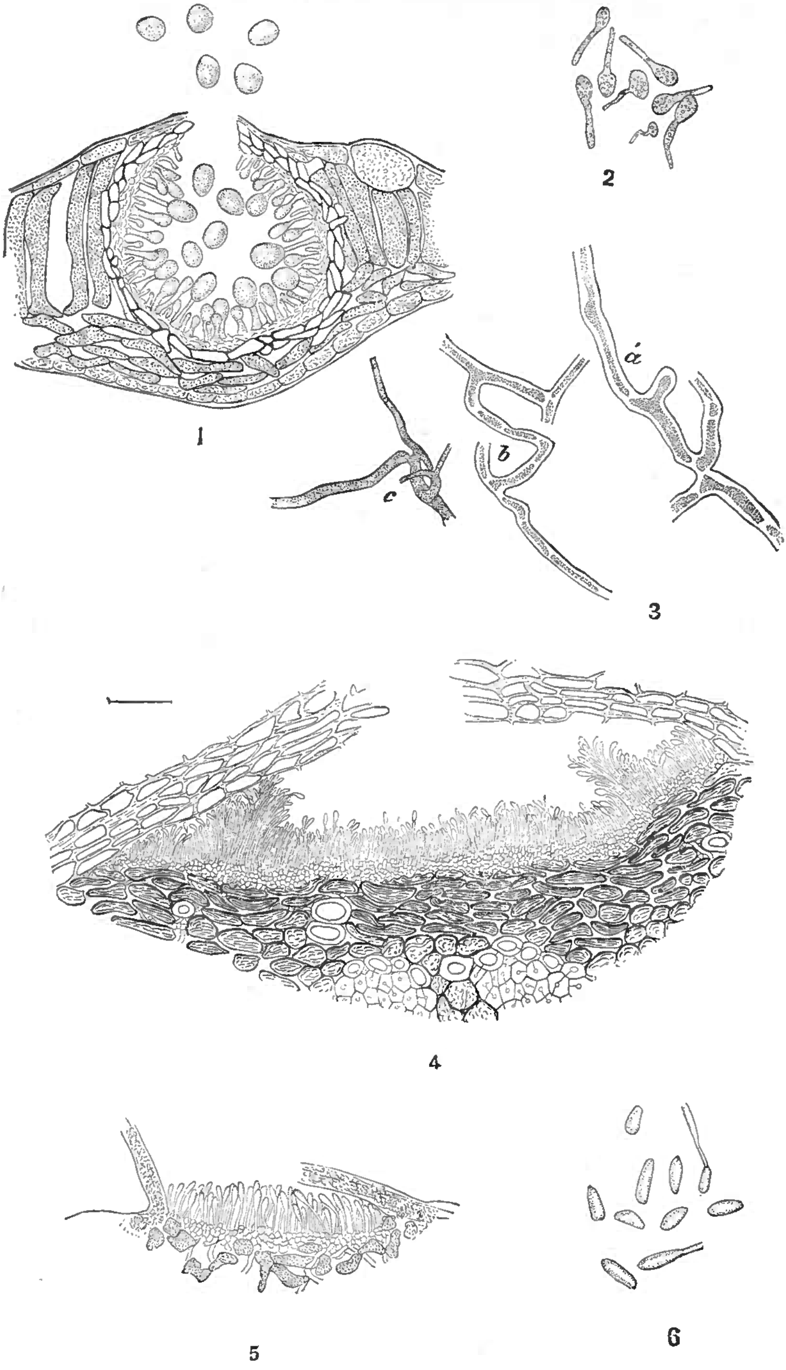
5

GRAPE SEPTOSPORIUMS (SEPTOSPORIUM FUCKELII, THÜM.; S. HETEROSPORUM, ELL. & GALL.).

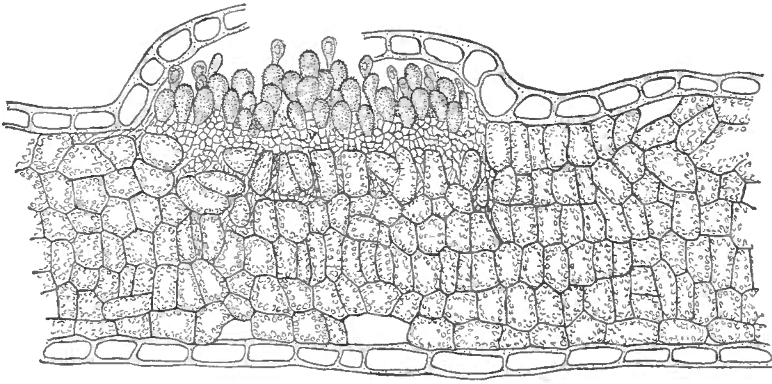
LEAF-SPOT DISEASE OF THE MAPLE.

PHYLLOSTICTA ACERICOLA, C. & E.

THE HATCH LITHO CO N Y



MAPLE LEAF BLIGHT AND SYCAMORE DISEASE (PHYLLOSTICTA ACERICOLA, C. & E., AND GLŒOSPORIUM NERVISEQUUM, SACC.).



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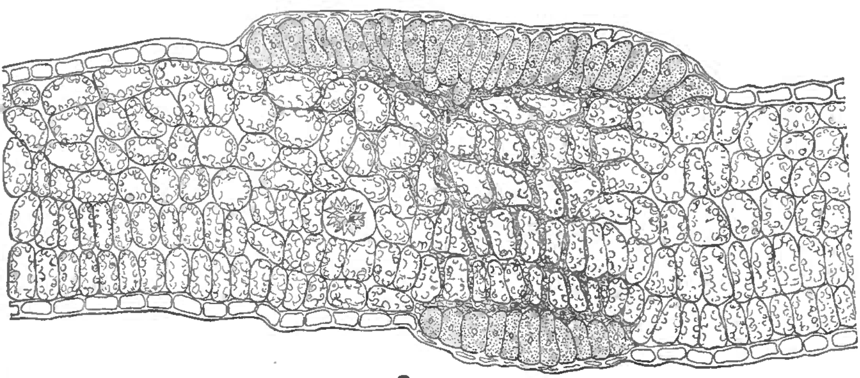

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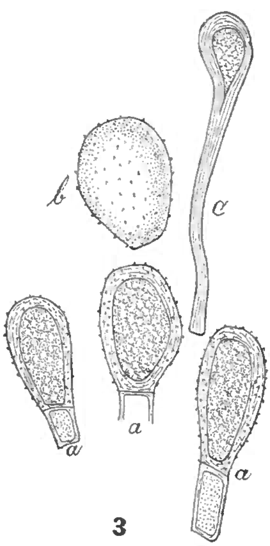

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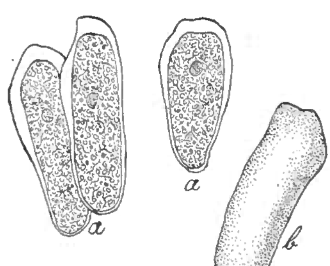

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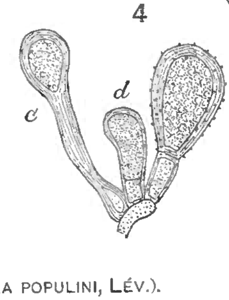

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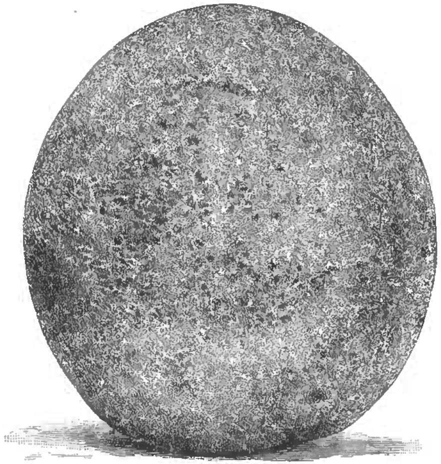
POPLAR LEAF RUST (MELAMPSORA POPULINI, LÉV.).

HEALTHY PEACH SHOOT—DELAWARE.

DISEASED PEACH SHOOTS—DELAWARE.

1



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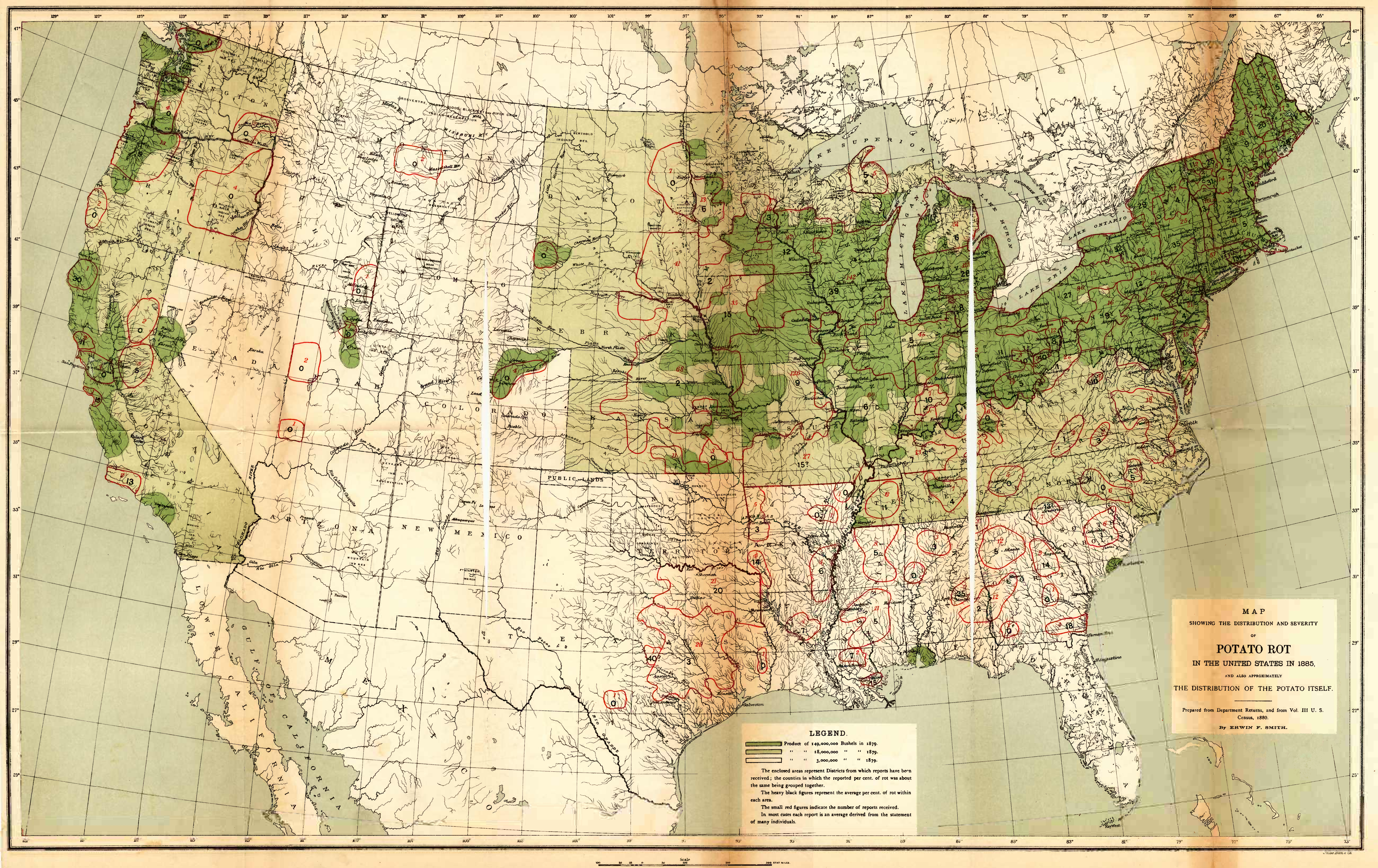
HEALTHY AND DISEASED PEACHES—DELAWARE.


MAP
SHOWING THE DISTRIBUTION AND SEVERITY
OF
POTATO ROT
IN THE UNITED STATES IN 1885,
AND ALSO APPROXIMATELY
THE DISTRIBUTION OF THE POTATO ITSELF.
Prepared from Department Returns, and from Vol. III U. S. Census, 1880.
By ERWIN F. SMITH.
LEGEND.
Product of 149,000,000 Bushels in 1879.
" " 18,000,000 " " 1879.
" " 3,000,000 " " 1879.
The enclosed areas represent Districts from which reports have been received; the counties in which the reported per cent. of rot was about the same being grouped together.
The heavy black figures represent the average per cent. of rot within each area.
The small red figures indicate the number of reports received.
In most cases each report is an average derived from the statement of many individuals.
LAKE SUPERIOR
LAKE MICHIGAN
LAKE HURON
LAKE ONTARIO
LAKE ERIE
NEBRASKA
COLORADO
NEW MEXICO
ARIZONA
NEVADA
GULF OF CALIFORNIA
PUBLIC LANDS
Galveston
Houston

REPORT OF THE STATISTICIAN.

SIR: I have the honor to submit my twentieth report as Statistician of this Department, a series including a record of the work of the Division of Statistics since 1866, with the exception of that in the years 1879 to 1881 inclusive.

The year has been one of great activity. The usual range of effort in domestic and foreign statistics has been traversed. The records of foreign official and other investigation have been materially enlarged during the year, and facilities for international comparisons have been much increased. The long-continued fiscal discussion during the last session of Congress made heavy demands upon this branch of the service. The legislator of the present day relies much upon the aid of statistics in the prosecution of his work, and has available a treasury of facts not attainable by the statesmen of the former generation.

The crop-reporting branch of the service, which includes a corps of county correspondents and their assistants, State agents and their assistants, and a foreign agent connected with our consular system, has somewhat extended its territory and enlarged its work. The county correspondents now number 2,331, their assistants are fully three times as many, and the State agencies have a large list of correspondents. Altogether over twelve thousand persons are connected with the work of statistical investigation. The State agencies are relied upon for duplication of the principal work of the county correspondents, for comparison and verification, and neither result is authoritative as against the other, but any discrepancies are adjusted with reference to consistency and probability. The State system, though useful and necessary, especially for local and special investigation, has as many separate heads as there are States, possessing different degrees of efficiency and value in experience, and therefore lacks unity and equality in accuracy. The Statistician consequently finds the regular corps of reporters an invaluable resource as a balance-wheel. It is found that the agents of greatest skill and experience agree more closely with our direct returns than do those of less experience. Even if there were but one system of returns, that of State agents and their correspondents, their work would be so various in mode and result as to be unequal and chaotic, without the direction, revision, and control of one central head. There may be forty local assistants, but not forty independent statisticians.

The public interested in crop reporting should not forget that a *census* of production can not be made in advance of growth and harvest. Neither can the perfect work of a complete census be obtained after harvest by local estimates of the best authorities. Many seem to think, in solemn verity, that estimates after careful observation, even guesses after casual glances at the crop area, may equal a thorough enumeration. They may have been led into this confident er-

ror by seeing several instances of our estimates of cotton and other products that have tallied almost exactly with subsequent count; nevertheless, entire accuracy by estimate can not be depended on.

What, then? Shall we have no check, by reasonable approximations, to the wild and baseless statements of persons interested in temporarily putting down and putting up prices? Men of this class, whose audacity equals their cupidity, write to the Department plainly expressing a desire that there may be no official returns or estimates. They are willing to spend money to get the best idea of future harvests that they can, by crude individual effort, but deprecate the collection of more accurate information, or any whatever, for the farmer, the consumer, and the carrier and forwarder. But the work will not cease and determine at the behest of this class of speculators.

Shall correspondents be paid? The idea has been frequently suggested, and the work is of sufficient importance to warrant a generous outlay. The unpaid service, for utility and practical value, possibly outranks other lines of expenditure which have amounted to many millions in recent years. Suppose $100 per annum should be allotted to each county reported by our regular staff. It would be a paltry compensation for good service for twelve months, for one person, and more insignificant for four, but this would cost $233,000. It is earned and would be cheap for the service rendered. There is an objection, also, that may or may not be valid. It is certain that there would be a scramble for the hundred dollars, under this plan, and almost equally certain that a most incompetent and self-seeking individual would secure influential indorsement, and render the responsibility of appointment a difficult and thankless burden, and the result in many instances, however careful and honest the effort, an inferior and unprofitable selection. The present plan is to obtain the services of the most observant farmer of the best judgment, of greatest promptness, who is willing to serve in a great corps of agricultural educators for the public good, and the especial illumination of the district which he represents. The best is none too good, and whatever the politics, religion, age, sex, or condition of one clearly entitled to this distinction, that person is the one, and the only one, that is wanted for county correspondent.

CURRENT CROP STATISTICS.

The year has not been exempt from checks to production, floods, blights, and insect depredations. It has not produced an extraordinary development in any of the growths of the year. Some products are in medium volume, others slightly below; yet there is no failure in any line of production. There has been as much exemption from continued high temperature, with deficient rain-fall, as could be expected in a domain so broad and various in its meteorological influences.

The drought of 1887, it is believed, increased the production of the present year by bringing near the surface from the lower stratum of the soil fertilizing elements not otherwise available. The long-continued evaporation incident to a dry season facilitates aeration and deepens its sphere of operation. The production of the year has undoubtedly been benefited by this cause.

The rain-fall of 1888 is quite in contrast with the precipitation of 1887. It was deficient almost everywhere in that season of drought,

and has this year been above normal in New England, Middle Atlantic and Gulf coast districts, nearly normal in the Ohio Valley and Tennessee, with a slight deficiency in the great region west of the Missouri to the Pacific coast, and a greater deficiency in the lake regions and in the South Atlantic States, the rain-fall being less than in 1887 by 2.02 inches in the cotton district. The comparison, from signal-service records, is as follows:

Districts.	Rain-fall.			Departure of 1888 from the normal.
	For a series of years.	For 1888.	For 1887.	
	Inches.	*Inches.*	*Inches.*	*Inches.*
New England	21.91	22.95	20.11	+1.02
Middle Atlantic	23.35	24.86	23.34	+1.51
South Atlantic	31.66	26.52	28.54	−5.14
Eastern Gulf	31.16	34.83	28.05	+3.67
Western Gulf	23.85	28.76	18.25	+4.91
Ohio Valley and Tennessee	23.07	22.45	19.40	−0.62
Lower Lake region	19.11	15.98	13.95	−3.13
Upper Lake region	20.07	16.26	13.51	−3.81
Extreme Northwest	14.16	12.70	14.07	−1.46
Upper Mississippi Valley	23.01	22.73	15.37	−0.28
Missouri Valley	21.68	19.75	19.31	−1.93
North Pacific coast	14.95	13.70	14.77	−1.25

The contrast in the record of the two years in the western Gulf district is very great. The rain-fall was 5.69 inches less than normal in 1887 and 4.91 above in 1888. It is the highest record except that of the eastern Gulf States, and falls short of that only 6.07 inches. The average of all districts makes the rain-fall of the year less than normal by a very slight deficiency.

Average rain-fall by districts.

Districts.	April.		May.		June.		July.		August.		September.	
	For several years.	1888.	For several years.	1888.	For several years.	1888.	For several years.	1888.	For several years.	1888.	For several years.	1888.
	Ins.	*Ins.*	*Ins.*	*Ins.*	*Ins.*	*Ins.*	*Ins.*	*Ins.*	*Ins.*	*Ins.*	*Ins.*	*Ins.*
New England	3.69	2.28	3.44	4.83	3.39	1.68	4.11	2.55	4.29	4.14	2.99	7.47
Middle Atlantic States	3.49	2.00	3.16	5.19	3.81	3.20	4.45	2.93	4.76	5.07	3.68	6.47
South Atlantic States	3.78	1.10	3.78	5.12	5.47	2.80	6.21	4.27	6.90	4.88	5.52	8.35
Florida Peninsula	2.12	0.62	3.18	2.18	6.21	2.87	6.70	6.58	6.16	2.89	5.53	9.17
Eastern Gulf States	5.62	1.96	4.30	6.24	6.45	6.96	5.28	3.06	5.44	11.36	4.07	5.25
Western Gulf States	4.22	5.01	4.84	5.02	3.55	6.29	3.24	2.96	3.54	8.10	4.46	1.38
Rio Grande Valley	0.72	4.14	3.60	1.54	2.57	3.48	1.81	0.97	3.86	1.18	6.22	6.50
Ohio Valley and Tennessee	4.23	2.72	3.78	3.82	4.34	3.11	4.17	3.28	3.63	6.82	2.92	2.70
Lower Lake Region	2.35	1.94	3.19	2.20	3.73	3.56	3.49	2.63	3.24	3.17	3.11	2.48
Upper Lake Region	2.35	2.49	3.31	3.47	4.14	2.44	3.34	2.62	3.27	2.08	3.66	2.56
Extreme Northwest	1.83	0.67	2.26	0.91	3.12	6.22	3.26	3.06	2.43	1.28	1.26	0.56
Upper Mississippi Valley	2.99	2.47	3.99	6.10	5.26	4.61	3.77	4.49	3.29	3.65	3.71	1.41
Missouri Valley	3.03	1.88	3.63	6.17	4.54	3.55	3.93	3.13	3.36	4.65	3.19	0.37
Northern Slope	1.27	1.05	1.94	2.85	2.55	3.83	1.72	1.50	1.52	1.29	1.18	0.58
Middle Slope	2.28	2.69	3.99	3.05	3.55	2.15	3.24	2.42	3.07	2.93	2.26	1.12
Southern Slope	1.37	2.92	2.28	2.00	3.05	2.51	2.88	2.00	3.51	5.39	3.15	0.93
Southern Plateau	0.42	0.38	0.34	0.38	0.50	0.13	1.20	1.27	2.24	0.77	1.25	0.42
Middle Plateau	1.72	0.59	1.26	1.02	1.02	0.78	0.51	0.41	0.85	0.65	0.66	0.27
Northern Plateau	1.88	0.40	1.22	1.75	1.45	2.96	0.40	0.55	0.51	0.20	0.91	0.41
North Pacific Coast Region	3.25	2.00	3.27	0.82	1.90	6.22	1.52	2.09	1.02	0.52	3.99	2.05
Middle Pacific Coast Region	2.86	0.25	0.73	0.43	0.30	0.99	0.01	0.03	......	......	0.85	0.62
South Pacific Coast Region	1.59	0.11	0.42	0.14	0.11	0.02	0.02	0.02	0.10	0.05	0.04	0.04

The temperature of the growing season has been below the normal. In April it was slightly above in the South Atlantic, Gulf, Ohio Valley, Missouri Valley, and Pacific coast districts; in May, everywhere below except on the North Pacific coast; in June, only in the Middle Atlantic, Ohio Valley, Lake regions, and North Pacific coast; in July, below normal everywhere east of the Missouri; in August, deficient in every district except the Pacific coast; and in September the extreme Northwest and the Pacific coast are the only exceptions.

Average temperature by districts.

Districts.	April.		May.		June.		July.		August.		September.	
	For several years.	1888.	For several years.	1888.	For several years.	1888.	For several years.	1888.	For several years.	1888.	For several years.	1888.
	°	°	°	°	°	°	°	°	°	°	°	°
New England	43.5	40.6	54.3	51.3	63.5	63.5	69.5	65.2	67.8	66.2	61.3	57.9
Middle Atlantic States	51.2	50.7	62.9	60.7	71.0	71.7	75.6	72.2	73.2	73.2	66.7	63.6
South Atlantic States	62.3	63.8	71.0	70.2	77.3	76.9	80.3	77.5	78.7	78.0	73.1	71.4
Florida Peninsula	72.6	73.2	77.5	76.9	81.5	81.0	83.4	82.0	83.0	82.4	81.1	78.9
Eastern Gulf States	65.8	68.2	73.0	71.7	79.0	77.3	80.6	80.5	79.9	78.3	74.4	72.0
Western Gulf States	66.5	68.9	73.2	72.0	79.7	78.0	82.0	81.2	81.0	79.9	75.4	72.7
Rio Grande Valley	73.0	74.4	79.0	78.3	83.4	81.0	84.5	82.0	82.9	81.7	77.6	75.6
Ohio Valley and Tennessee	56.3	57.9	66.6	64.2	73.3	73.7	77.0	76.2	75.0	73.6	67.7	63.5
Lower Lake Region	43.9	42.2	57.5	54.4	66.1	66.9	71.0	69.1	68.8	68.2	63.1	58.4
Upper Lake Region	40.3	38.8	53.3	48.2	62.1	63.0	68.0	67.1	66.0	64.6	58.9	55.2
Extreme Northwest	38.4	38.3	54.4	48.1	64.4	62.9	67.4	67.6	64.8	62.3	52.4	54.4
Upper Mississippi Valley	51.5	51.1	62.9	56.6	70.9	69.8	75.2	75.3	73.0	69.8	63.2	59.3
Missouri Valley	48.5	51.0	61.3	54.9	69.9	69.0	73.8	75.6	71.2	68.8	61.5	60.3
Northern Slope	42.4	46.5	53.3	49.9	62.7	61.4	67.9	68.4	66.5	64.6	54.1	58.7
Middle Slope	51.8	56.3	60.6	58.9	70.7	72.8	75.5	77.1	73.2	71.1	63.5	64.0
Southern Slope	61.3	63.2	69.7	67.7	78.1	76.8	79.7	78.4	77.3	76.8	68.6	66.1
Southern Plateau	56.4	61.8	65.6	64.9	74.0	75.9	78.0	77.6	75.6	76.3	69.0	71.4
Middle Plateau	47.4	55.0	56.5	57.7	65.5	65.8	73.6	74.4	72.0	73.0	62.3	68.9
Northern Plateau	49.4	55.4	57.7	61.5	64.7	63.6	71.0	71.0	69.3	73.5	58.3	66.1
North Pacific Coast Region	47.8	51.6	52.7	55.7	57.6	58.7	60.0	61.2	59.3	62.5	56.4	61.6
Middle Pacific Coast Region	56.0	50.1	61.0	59.6	68.0	64.6	71.2	70.5	69.7	72.3	66.6	71.3
South Pacific Coast Region	57.6	61.4	62.0	61.0	65.0	66.7	67.0	68.2	69.5	68.0	64.5	68.8

The following table makes a statement of temperature, in connection with rain-fall, showing the departure from the normal.

Districts.	April.		May.		June.		July.		August.		September.	
	Temperature.	Rain-fall.	Temperature.	Rain-fall.	Temperature.	Rain-fall.	Temperature.	Rain-fall.	Temperature.	Rain-fall.	Temperature.	Rain-fall.
	°	*Ins.*	°	*Ins.*	°	*Ins.*	°	*Ins.*	°	*Ins.*	°	*Ins.*
New England	−2.9	−1.41	−3.0	+1.39	0.0	−1.71	−4.3	−1.56	−1.6	−0.15	−3.4	+4.48
Middle Atlantic	−0.5	−1.49	−2.2	+2.03	+0.7	−0.61	−3.4	−1.52	0.0	+0.31	−3.1	+2.79
South Atlantic	+1.5	−2.68	−0.8	+1.34	−0.4	−2.67	−2.8	−1.94	−0.7	−2.02	−1.7	+2.83
Eastern Gulf	+2.4	−3.66	−1.3	+1.94	−1.7	+0.51	−0.1	−2.22	−1.6	+5.92	−2.4	+1.18
Western Gulf	+2.4	+0.79	−1.2	+0.18	−1.7	+2.74	−0.8	−0.28	−1.1	+4.56	−2.7	−3.08
Ohio Valley and Tennessee	+1.6	−1.51	−2.4	+0.04	+0.4	−1.23	−0.8	−0.89	−1.4	+3.19	−4.2	−0.22
Lower Lake Region	−1.7	−0.41	−3.1	−0.99	+0.8	−0.17	−1.9	−0.86	−0.6	−0.07	−4.7	−0.63
Upper Lake Region	−1.5	+0.14	−5.1	+0.16	+0.9	−1.70	−0.9	−0.72	−1.4	−0.59	−3.7	−1.10
Extreme Northwest	−0.1	−1.16	−0.3	−1.35	−1.5	+3.10	+0.2	−0.20	−2.5	−1.15	+2.0	−0.70
Upper Mississippi Valley	−0.4	−0.52	−6.3	+2.11	−1.1	−0.65	+0.1	+0.72	−3.2	+0.36	−3.9	−2.30
Missouri Valley	+2.5	−1.15	−6.4	+2.54	−0.9	−0.99	+1.8	−0.80	−2.4	+1.29	−1.2	−2.82
North Pacific Coast	+3.8	−1.25	+3.0	−2.45	+1.1	+4.32	+1.2	+0.57	+3.2	−0.50	+5.2	−1.94
Middle Pacific Coast	+3.1	−2.61	−1.4	−0.30	−3.4	+0.69	−0.7	+0.02	+2.6	......	+4.7	+0.27

The amount of heat required to ripen different crops is an important question in practical agricultural meteorology. The first requisite for its study is a record of the effective daily and monthly aggregates of heat. While it would doubtless account measurably for differences in yield of such crops as corn or cotton, which require more heat than many others, its proper distribution through the season would probably modify the result, and other meteorological conditions would also require consideration.

CROPS OF THE YEAR.

The increase of population requires annually larger crops. The area devoted to cereals has been enlarged by a considerable extension of the crops of corn and oats. The other cereals are almost exclusively used as human food, the demand for which is uniform. Corn and oats are mainly used in feeding of animals for milk and meat and motive power, enjoying a vastly more elastic demand and having a widely extended range of uses. The result of increase of area, with a medium rate of yield, is a larger aggregate product of cereals than has ever before been recorded. It will amount to about 3,200,000,000 bushels, or about 51 bushels per head. This is about three times the average supply per capita of Europe from home production, which is supplemented by receipts from other continents amounting to only about one bushel per head. So nearly is Europe self-supporting. So liberal are the supplies of the United States. So hopeless is the expectation greatly to enlarge permanently our volume of exports. Rice is a minor cereal of local importance; the present crop is not very large.

Next to cereals in importance of production for food supply are potatoes. The unthinking public jumped to the conclusion that reduction of yield in recent years, the last especially, foreboded a permanent scarcity, either from loss of vitality in the stock or degeneracy of the soil. The present crop is a large one, the aggregate coming well up towards 200,000,000 bushels. The sweet-potato crop, which is also a very valuable food product, has been a good one, especially in the more southern tier of States. The crop was less abundant in Virginia, North Carolina, and Kentucky. It is not closely estimated, but doubtless exceeds 40,000,000 bushels.

The season has not been favorable to cane sugar, and production is limited in consequence. Sugar planters are now considering with interest the evolution in sugar making promised by the diffusion process. Hitherto the business has illustrated conspicuously the wastes of American agriculture, as scarcely more than half of the saccharine contents of the plant has been obtained during a century of development of the industry.

The cane crop of 1888 has not been a good one. The stubble especially is small and cracked, and the yield has not been very satisfactory. It is believed that the ultimate record of production will be materially less than for the season of 1887-'88, when the product was 285,158 hogsheads, weighing 353,855,877 pounds net, the largest crop since 1861, which was 459,419 hogsheads. The crops of 1852, 1853, 1854, and 1858 were also larger. The product of molasses was 21,980,241 gallons.

The sorghum crop varies in different sections, but may be considered a medium crop. It is a valuable resource for sirup for local

use, supplementing the supply, though little used in cities. It has not yet paid its way as a sugar plant, no factories having so far proved self-sustaining without Government aid. A hopeful feeling is prevalent that, through diffusion and other aids to manufacture, its ultimate success will be assured.

Beet sugar is apparently on the eve of extensive production in California, if the enterprise of Claus Spreckels is as successful as it is represented. One factory, that at Alvarado, has been in successful operation there for a dozen years, though it did not run last year on account of destruction of machinery by an explosion.

The abundant moisture of the season has been favorable to hay, and the moderate temperature of spring was also conducive to heavy growth, and the crop is therefore a large one.

The cotton crop is one of medium yield, with increased acreage. The crop was later in development than that of 1887, and the growing season was shorter. Condition, in October, however, was quite as high as in October of 1887. Notwithstanding the large supply of the past two years the demand is quite as strong as a year ago, the average export price in December being 10.01 cents, against 9.80 cents in December of 1887.

The season has been favorable for vegetables, and a large and cheap supply is found in the markets.

Fruits have been fairly abundant, though variable in production locally. It is the "even year," and apples are plenty for domestic use, while their cheapness has favored exportation.

The wool clip of 1888 was slightly reduced, in consequence of the reduction of flocks in Texas and elsewhere. The estimated product is 265,000,000 pounds.

The meat supply has been very abundant, and the price on the hoof too low in the Western markets and too high in the retail markets of the East. The middlemen get too large a slice of the profits, and the farmer accepts either a small profit or a slight loss.

It has been, on the whole, a fairly prolific and prosperous season for American agriculture.

CORN.

The area of maize, as estimated for the crop of 1888, makes an increase of 3,280,043 acres over the crop of 1887, and 13,304,259 acres over the census crop of 1879; indicating a gain of 21 per cent. in nine years. It is not believed that this is an overestimate. The constant tendency of local estimators to understate the area of crops has been combated from year to year with caution and conservatism, and yet it is possible that the above estimate may be found too low. It is certain that it is not equal to the increase of population, which must be about 26 per cent. While it is scarcely expected that the area in cereals will keep pace with population, the home demand for corn is so various and imperative that the relative decline should not be very heavy. The estimate for 1888 is 75,672,763 acres; an area more than three-fourths as large as the combined areas in wheat of all the countries of Europe, and nearly twice as large as the acreage in maize in all the other countries of Europe and America.

The planting was late on the Atlantic slope, delayed by too much moisture in the soil and by low temperature. Similar conditions, less general and injurious, prevailed through the Central States. In portions of Texas there was delay in planting from excessive rains.

Irregular precipitation (drought followed by excess of moisture) affected planting and growth in some sections of Louisiana. As a rule, however, conditions favorable to seeding and development were general on the Gulf coast.

The averages of condition for the whole country illustrate the marked differences which appear in the records of the past two years. They are as follows:

Years.	July.	August.	September.	October.
1887	97.7	80.5	72.3	72.8
1888	93.0	95.5	94.2	92.0

Moderately favorable conditions have prevailed through the year. Late planting and a comparatively cool season prevented unusual development and a high rate of yield. The result is 26.3 bushels per acre, 26 being an average. The crop of the previous year started still better, but encountered during July the commencement of one of the worst periods of drought which have ever scourged the central corn-growing States, continuing through August, and practically through the season.

The differences in figures of condition in the corn-surplus States are still more striking:

States.	July.		August.		September.		October.	
	1887.	1888.	1887.	1888.	1887.	1888.	1887.	1888.
Ohio	96	96	82	98	68	99	70	99
Indiana	98	95	64	99	61	99	61	98
Illinois	98	93	65	96	57	98	60	98
Iowa	99	89	90	98	78	99	78	99
Missouri	99	91	80	94	67	92	70	92
Kansas	100	99	60	91	42	80	45	77
Nebraska	100	91	75	96	72	97	67	97

These States, so much worse in condition of corn than other parts of the country in 1887, are decidedly better than other States in 1888, occupying extreme positions in this respect during both seasons, except in July of 1887. The difference in product, as estimated, is as follows:

States.	1887.	1888.	States.	1887.	1888.
Ohio	73,797,000	93,018,000	Kansas	76,547,000	158,186,000
Indiana	71,400,000	125,478,000	Nebraska	93,150,000	144,217,000
Illinois	141,080,000	278,060,000	Surplus corn States	780,425,000	1,279,774,000
Iowa	183,502,000	278,232,000	United States	1,456,161,000	1,987,790,000
Missouri	140,949,000	202,583,000			

In 1887 the proportion produced in these Central States was 54 per cent., while in 1888 the proportion was 64 per cent., nearly twice as much in seven States as in thirty-one States and all the Territories.

The estimates of the crop of 1888 are as follows:

States and Territories.	Bushels.	Acres.	Value.
Maine	596,000	30,878	$447,000
New Hampshire	846,000	37,421	609,120
Vermont	1,494,000	61,470	986,040
Massachusetts	1,788,000	59,397	1,215,840
Rhode Island	382,000	12,558	267,400
Connecticut	1,778,000	56,977	1,155,700
New York	22,870,000	705,859	13,264,600
New Jersey	11,351,000	350,335	6,016,030
Pennsylvania	45,414,000	1,397,350	22,707,000
Delaware	3,844,000	220,927	1,691,360
Maryland	17,553,000	740,645	7,898,850
Virginia	34,745,000	2,131,595	17,025,050
North Carolina	28,343,000	2,673,910	16,438,940
South Carolina	13,715,000	1,576,388	8,229,000
Georgia	28,069,000	2,923,885	16,841,400
Florida	4,541,000	463,392	2,951,650
Alabama	31,616,000	2,489,475	17,388,800
Mississippi	28,422,000	1,933,477	15,347,880
Louisiana	15,263,000	1,031,263	8,089,390
Texas	92,436,000	4,814,363	37,898,760
Arkansas	41,543,000	2,130,399	19,940,640
Tennessee	75,665,000	3,637,762	31,779,300
West Virginia	16,149,000	678,518	7,751,520
Kentucky	81,545,000	3,160,668	27,725,300
Ohio	93,018,000	2,862,080	32,556,300
Michigan	29,025,000	967,513	12,190,500
Indiana	125,478,000	3,605,694	38,898,180
Illinois	278,060,000	7,788,790	80,637,400
Wisconsin	32,733,000	1,069,717	11,783,880
Minnesota	20,622,000	703,837	6,599,040
Iowa	278,232,000	7,771,840	66,775,680
Missouri	202,583,000	6,534,921	60,774,900
Kansas	158,186,000	5,924,566	41,128,360
Nebraska	144,217,000	4,097,067	31,727,740
California	4,314,000	155,184	3,019,800
Oregon	161,000	7,140	109,480
Colorado	777,000	34,394	442,890
Dakota	18,816,000	737,899	6,209,280
New Mexico	992,000	53,609	664,640
Utah	486,000	33,500	306,180
Washington	122,000	6,100	70,760
Total	1,987,790,000	75,672,763	677,561,580

The home consumption varies greatly with the product, being affected by price. It was reduced last year from relative scarcity and high price. Since 1879 the average consumption has averaged about 27 bushels per annum for each unit of population; for ten years preceding, 25 bushels. There will be a supply for the current year, beyond the probable foreign demand, of 30 bushels per capita.

The average production for ten years, 1870 to 1879 inclusive, was 1,184,486,954 bushels; of the nine years of the present decade, 1,657,948,726 bushels, an increase of 40 per cent. Deducting 55,077,828 bushels per annum exported in the former period, and 51,292,327 bushels per annum in the latter, the average quantities left for consumption are respectively 1,129,409,126 and 1,606,656,399 bushels, an increase of 42 per cent., which is much greater than the increase of population. The decrease is doubtless only a temporary difference between the unusual requirements for feeding material in Western Europe, between 1876 and 1880, and the somewhat reduced demand under more normal conditions of agricultural production in later years. There appears to be no great probability of heavy exportation in the immediate future.

The average value of corn for nine years has been 40.8 cents per bushel, against 42.6 cents for the ten years preceding. That this decrease in average value is so slight, with an enlarged per capita supply, is due to the increased use of corn for the various products

into which it enters. The average yield per acre, 23.8 bushels instead of 27.1 bushels, is emphatically not the result of soil deterioration, but of a series of crop reductions from meteorological causes, producing great variation annually, with only three of the nine above an average, that of 1887 being 20.1 bushels, and that of 1888 being 26.3 bushels. The average value of an acre of corn is made $9.71, against $11.54 for the former period. The reduction in value comes from a reduced rate of yield and a lower price. The following table gives the area, product, and value of all crops since 1879:

Years.	Total production.	Total area of crop.	Total value of crop.	Average value per bushel.	Average yield per acre.	Average value per acre.
	Bushels.	*Acres.*		*Cents.*	*Bushels.*	
1880	1,717,434,543	62,317,842	$679,714,499	39.6	27.6	$10.91
1881	1,194,916,000	64,262,025	759,482,170	63.6	18.6	11.82
1882	1,617,025,100	65,659,545	783,867,175	48.4	24.6	11.94
1883	1,551,066,895	68,301,889	658,051,485	42.4	22.7	9.63
1884	1,795,528,000	69,683,780	640,735,560	35.7	25.8	9.19
1885	1,936,176,000	73,130,150	635,674,630	32.8	26.5	8.69
1886	1,665,441,000	75,694,208	610,311,000	36.6	22.0	8.06
1887	1,456,161,000	72,392,720	646,106,770	44.4	20.1	8.93
1888	1,987,790,000	75,672,763	677,561,580	34.1	26.3	8.95
Total	14,921,538,538	627,114,922	6,091,504,869	....	....	....
Annual average	1,657,948,726	69,679,436	676,833,874	40.8	23.8	9.71
Annual average for preceding ten years	1,184,486,954	43,741,331	504,571,048	42.6	27.1	11.54

This table shows the fluctuation and increase in product, and places the last highest in the record of volume, though the rate of yield is only medium, and the quality somewhat inferior. The exports of corn (including corn meal) from the crop of 1887 were smaller than in any other year since 1870, being only 25,360,869 bushels.

The following table shows the proportion of each crop annually exported since 1869:

Production and export of corn.

Years.	Production.	Exports.	Exportation.	Years.	Production.	Exports.	Exportation.
	Bushels.	*Bushels.*	*Per cent.*		*Bushels.*	*Bushels.*	*Per cent.*
1849*	592,071,104	7,632,860	1.3	1879	1,754,591,676	99,572,329	5.7
1859*	838,792,742	4,248,991	.5	1880	1,717,434,543	93,648,147	5.5
1869*	760,944,549	2,140,487	.3	1881	1,194,916,000	44,340,683	3.7
1870	1,094,255,000	10,673,553	1.0	1882	1,617,025,100	41,655,653	2.6
1871	991,898,000	35,727,010	3.6	1883	1,551,066,895	46,258,606	3.0
1872	1,092,719,000	40,154,374	3.7	1884	1,795,528,000	52,876,456	2.9
1873	932,274,000	35,985,834	3.9	1885	1,936,176,000	64,829,617	3.3
1874	850,148,500	30,025,036	3.5	1886	1,665,441,000	41,368,584	2.5
1875	1,321,069,000	50,910,532	3.9	1887	1,456,161,000	25,360,869	1.7
1876	1,283,827,500	72,652,611	5.7				
1877	1,342,558,000	87,192,110	6.5	Annual average	1,388,072,665	53,395,383	3.8
1878	1,388,218,750	87,884,892	6.3				

* Census.

The extreme range of annual variation of volume will attract the attention of the reader—from 2,000,000 bushels (in round numbers) to 100,000,000 bushels. It is no surprise to any one who understands the causes affecting the movement. The great controlling factor in producing the extremes named was price, which was in the fiscal year 1870, 92.5 cents at the ports of shipment, and in 1880 it was only 54.3 cents. In the former case the high domestic price pre-

vented exportation; in the latter, the unprecedented cheapness of corn greatly increased foreign demand. Its sale in Europe is dependent on its relative cheapness as a feeding material for animals. The Liverpool price is made in America; the American price never in Liverpool. The average effect of 3.8 per cent. of foreign demand would naturally increase the price of the crop a fraction over one cent per bushel.

WHEAT.

The estimate of wheat area makes a reduction of 305,645 acres from the breadth of 1887. The aggregate is 37,336,138; an increase of only 1,905,805 on the area of 1879, or little more than 5 per cent. The exports will probably be less than those of 1879-'80 by at least 100,000,000 bushels; a quantity more than ample for the annual supply of all the increase of population since 1880. Should the area be advanced in similar ratio in the next ten years, an average rate of yield would barely suffice for home consumption. The area will certainly increase in the future, but not rapidly, unless under the stimulus of a larger foreign demand than present circumstances controlling the production of the world would seem to warrant.

The winter-wheat crop had a very unpromising appearance on the 1st of April, and its condition averaged 82, and was still further reduced to 73.1 on the 1st of May, indicating a status quite unfavorable, and a probable low rate of yield. The seed bed was generally very dry in the autumn of 1887, the soil cloddy, the sowing slow, the germination irregular, the growth uneven, and the plant generally in poor condition to endure the ordinary vicissitudes of winter. As the season wore on, under more favorable meteorological conditions, improvement was noted; and though the development of straw was inferior, the grain yielded more in thrashing than was expected, so that the final average was 11.6 bushels per acre, when 11 bushels would have been deemed a good outcome at any time during the spring. The condition of winter wheat, contrasted with that of the crop of 1887, is as follows:

Years.	April.	May.	June.	July.	Sept.*
1887	88.1	85.8	84.9	83.5	84.0
1888	82.0	73.1	73.3	75.6	77.4

*Condition when harvested.

The weather of April, instead of improving the condition of wheat, gave it a worse appearance, which naturally depressed the local estimates. It is evident that the roots had more vitality than the stunted and discolored plants indicated, rendering possible a slight recuperation, and to that extent agreeably disappointing the hopes of the growers.

The condition of spring wheat through June and July was better in 1888 than in the previous year. It suffered serious injury early in August, as illustrated by the following averages:

Years.	June.	July.	August.	September.
1887	87.3	79.3	78.8	78.1
1888	92.8	95.9	87.3	77.2

It is seen that the decline commenced in July. The chinch-bug was in strong force in many counties in Wisconsin, Iowa, and Nebraska, doing no little damage. Local droughts, storms of rain in other localities, blights, rusts, and the army worm, were responsible each for a share in the reduction of condition. The weather of August was very unfavorable, causing shriveling and blight, early frosts devastating some portions of the valleys of the Red and James Rivers, and insects in limited areas assisted in reducing the rate of yield. The damage was not overstated; the returns of yield per acre gave even lower results than the forecast of the September returns, due measurably to injury to wheat after harvest between cutting and thrashing.

The estimates of wheat are in detail as follows:

States and Territories.	Bushels.	Acres.	Value.
Maine	589,000	40,644	$706,800
New Hampshire	152,000	10,380	182,400
Vermont	346,000	20,710	408,280
Connecticut	32,000	2,149	38,400
New York	9,309,000	660,214	10,239,900
New Jersey	1,785,000	141,652	1,963,500
Pennsylvania	18,802,000	1,392,728	20,118,140
Delaware	1,194,000	94,790	1,194,000
Maryland	7,634,000	557,208	7,634,000
Virginia	5,172,000	623,121	5,172,000
North Carolina	3,835,000	710,268	4,026,750
South Carolina	973,000	194,563	1,089,760
Georgia	1,910,000	374,452	2,101,000
Alabama	2,186,000	420,443	2,295,300
Mississippi	532,000	84,875	558,600
Texas	6,066,000	572,226	6,066,000
Arkansas	2,267,000	233,671	2,153,650
Tennessee	10,297,000	1,211,394	9,576,210
West Virginia	2,899,000	305,199	2,783,040
Kentucky	10,436,000	1,013,228	10,018,560
Ohio	28,705,000	2,657,884	27,843,850
Michigan	24,028,000	1,645,762	23,547,440
Indiana	28,879,000	2,774,062	27,206,260
Illinois	33,556,000	2,449,343	31,207,080
Wisconsin	13,855,000	1,204,798	13,800,800
Minnesota	27,881,000	3,097,916	25,650,520
Iowa	24,196,000	2,468,982	20,566,600
Missouri	18,496,000	1,541,343	16,276,480
Kansas	15,960,000	1,050,000	14,044,800
Nebraska	14,508 000	1,560,021	12,041,640
California	28,451,000	2,351,300	24,183,350
Oregon	14,548,000	892,425	11,347,440
Nevada	200,000	12,500	184,000
Colorado	2,346,000	134,074	2,111,400
Arizona	370,000	24,695	333,000
Dakota	38,036,000	3,921,269	34,612,760
Idaho	1,252,000	76,818	1,089,240
Montana	2,001,000	121,255	1,700,850
New Mexico	1,233,000	82,186	1,171,350
Utah	1,945,000	119,299	1,478,200
Washington	9,006,000	486,791	7,024,680
Total	415,868,000	37,336,138	385,248,030

The average supply per man is nearly a bushel more in the present period than for the preceding decade. The decline in price has been nearly 20 per cent. The average rate of yield is very nearly the same, and differs little in different periods of several years, though fluctuating annually between 10 and 14 bushels per acre. The value per acre has of course materially declined, from $13 to $10.09 per acre. There is no increase in the area in eight years, as estimated, though the area in 1884 rose to the highest point during the period, and fell to the lowest the following year. The comparison is as follows:

Years.	Total production.	Total area of crop.	Total value of crop.	Average value per bushel.	Average yield per acre.	Average value per acre.
	Bushels.	*Acres.*		*Cents.*	*Bushels.*	
1880	498,549,868	37,986,717	$474,201,850	95.1	13.1	$12.48
1881	383,280,090	37,709,020	456,880,427	119.3	10.2	12.12
1882	504,185,470	37,067,194	444,602,125	88.2	13.6	11.99
1883	421,086,160	36,455,593	383,649,272	91.0	11.6	10.52
1884	512,765,000	39,475,885	330,862,260	64.5	13.0	8.38
1885	357,112,000	34,189,246	275,320,390	77.1	10.4	8.05
1886	457,218,000	36,806,184	314,226,020	68.7	12.4	8.54
1887	456,329,000	37,641,783	310,612,960	68.1	12.1	8.25
1888	415,868,000	37,336,138	385,248,030	92.6	11.1	10.32
Total	4,006,393,588	334,667,760	3,375,603,334			
Annual average	445,154,843	37,185,307	375,067,037	84.3	12.0	10.09
Annual average for preceding ten years	312,152,728	25,187,414	327,407,258	104.9	12.4	13.00

OATS.

There appears to be a further increase of the area of oats, amounting to 1,077,376 acres, and about 42,000,000 bushels increase in the quantity produced. The yield per acre is 26 bushels, against 25.4 bushels in 1887. The price has declined, as was inevitable in a year of so large a product of maize. The value, however, is quite well sustained, being 27.8 cents per bushel against 30.4 cents per bushel in December of 1887. The estimates by States are as follows:

States and Territories.	Bushels.	Acres.	Value.
Maine	2,656,000	96,933	$1,142,080
New Hampshire	1,033,000	34,086	454,520
Vermont	3,536,000	108,800	1,449,760
Massachusetts	705,000	25,000	317,250
Rhode Island	174,000	6,353	76,560
Connecticut	1,055,000	39,811	453,650
New York	40,570,000	1,398,957	15,010,900
New Jersey	3,688,000	140,218	1,327,680
Pennsylvania	35,251,000	1,330,234	11,985,340
Delaware	450,000	21,839	157,500
Maryland	2,296,000	118,976	757,680
Virginia	8,108,000	659,192	2,918,880
North Carolina	6,078,000	660,657	2,795,880
South Carolina	3,773,000	397,198	2,075,150
Georgia	7,115,000	618,687	3,770,950
Florida	599,000	53,021	365,390
Alabama	4,806,000	417,880	2,306,880
Mississippi	4,096,000	365,722	2,048,000
Louisiana	495,000	41,284	222,750
Texas	13,596,000	609,645*	4,350,400
Arkansas	5,135,000	285,273	2,156,700
Tennessee	11,108,000	677,340	3,998,880
West Virginia	2,495,000	145,051	898,200
Kentucky	8,454,000	491,496	2,789,820
Ohio	33,819,000	1,063,475	9,469,320
Michigan	26,668,000	803,250	8,000,400
Indiana	28,522,000	1,076,320	7,415,720
Illinois	137,400,000	3,838,000	31,602,000
Wisconsin	42,768,000	1,454,702	11,975,040
Minnesota	43,540,000	1,517,076	11,320,400
Iowa	67,090,000	2,560,683	13,418,000
Missouri	34,909,000	1,385,281	8,378,160
Kansas	42,654,000	1,685,926	9,383,880
Nebraska	26,177,000	1,014,606	4,973,630
California	1,866,000	73,760	1,119,600
Oregon	5,441,000	209,278	2,176,400
Nevada	206,000	8,094	129,780
Colorado	1,664,000	60,740	698,880
Arizona			
Dakota	34,218,000	1,258,008	8,896,680
Idaho	957,000	34,684	334,950
Montana	1,780,000	61,384	605,200
New Mexico	392,000	15,607	137,200
Utah	986,000	35,500	364,820
Washington	3,314,000	94,687	1,159,900
Wyoming	93,000	3,388	33,480
Total	701,735,000	26,998,282	195,424,240

The enlargement of area and increase of product have been very large since 1880. There is little difference in rate of yield. Price has declined, from increase of production both of corn and oats. The climate is not well suited to this crop, in the more southern latitudes, unless grown in the winter, which is now generally the case. This grain deteriorates rapidly, requiring frequent change of seed to prevent reduction of weight. Yet it is a very important crop, and its cultivation is relatively profitable.

The estimates of area, yield, and value are as follows:

Years.	Total production.	Total area of crop.	Total value of crop.	Average value per bushel.	Average yield per acre.	Average value per acre.
	Bushels.	*Acres.*		*Cents.*	*Bushels.*	
1880	417,885,380	16,187,977	$150,243,565	36.0	25.8	$9.28
1881	416,481,000	16,831,600	193,198,970	46.4	24.7	11.48
1882	488,250,610	18,494,691	182,978,022	37.5	26.4	9.64
1883	571,302,400	20,324,962	187,040,264	33.0	28.1	9.27
1884	583,628,000	21,300,917	161,528,470	28.0	27.4	7.58
1885	629,409,000	22,783,630	179,631,860	28.5	27.6	7.88
1886	624,134,000	23,658,474	186,137,930	29.8	26.4	7.87
1887	659,618,000	25,920,906	200,699,790	30.4	25.4	7.74
1888	701,735,000	26,998,282	195,424,240	27.8	26.0	7.24
Total	5,092,443,390	192,501,439	1,636,883,111	....	....	....
Annual average	565,827,043	21,389,049	181,875,901	32.1	26.5	8.50
Annual average for preceding ten years	314,441,178	11,076,822	111,075,223	35.3	28.4	10.03

RYE.

This country uses very little of this grain. It occupies an insignificant area, and does not increase in proportion to population. It is used mainly by people of German descent, and to a limited extent in the Eastern States in combination with maize. It is scarcely grown in the South, and but little in the West and on the Pacific coast. It is neither exported nor imported in quantities worth mentioning. In the South the crop is somewhat extensively grown for winter pasture, and whatever grain is harvested is largely used as seed. The annual course of production is thus indicated:

Years.	Total production.	Total area of crop.	Total value of crop.	Average value per bushel.	Average yield per acre.	Average value per acre.
	Bushels.	*Acres.*		*Cents.*	*Bushels.*	
1880	24,540,829	1,767,619	$18,564,560	75.6	13.9	$10.50
1881	20,704,950	1,789,100	19,327,415	93.3	11.6	10.80
1882	29,960,037	2,227,894	18,439,194	61.5	13.4	8.28
1883	28,058,582	2,314,754	16,300,503	58.0	12.1	7.04
1884	28,640,000	2,343,963	14,857,040	52.0	12.2	6.34
1885	21,756,000	2,129,301	12,594,820	57.9	10.2	5.92
1886	24,489,000	2,129,918	13,181,330	53.8	11.5	6.19
1887	20,693,000	2,053,447	11,283,140	54.5	10.1	5.49
Total	198,842,398	16,755,996	124,548,002	....	....	....
Annual average	24,855,300	2,094,500	15,568,500	62.6	11.9	7.43
Annual average for preceding ten years	18,460,985	1,305,061	12,945,136	70.1	14.1	9.92

BARLEY.

Of this grain less is grown than is consumed. It has increased materially in breadth and product, and still the imports have in-

creased in quite as large proportion. It gives a better return in value per acre than any other cereal. As in the case of nearly all farm products its value per bushel has declined in recent years. The rate of yield varies annually, but averages nearly twice as much as wheat. The following record shows the annual acreage, product, and value of barley:

Years.	Total production.	Total area of crop.	Total value of crop.	Average value per bushel.	Average yield per acre.	Average value per acre.
	Bushels.	*Acres.*		*Cents.*	*Bushels.*	
1880	45,165,346	1,843,329	$30,090,742	66.6	24.5	$16.32
1881	41,161,330	1,967,510	33,862,513	82.3	20.9	17.21
1882	48,953,926	2,272,103	30,768,015	62.8	21.5	13.54
1883	50,136,097	2,379,009	29,420,423	58.7	21.1	12.38
1884	61,203,000	2,608,818	29,779,170	48.7	23.5	11.41
1885	58,360,000	2,729,359	32,867,696	56.3	21.4	12.04
1886	59,428,000	2,652,957	31,840,510	53.6	22.4	12.00
1887	56,812,000	2,901,953	29,464,390	51.9	19.6	10.15
Total	421,219,699	19,355,038	248,093,459			
Annual average	52,652,462	2,419,380	31,011,682	58.9	21.8	12.82
Annual average for preceding ten years	33,704,652	1,529,357	24,885,503	73.8	22.0	16.27

The importations of recent years are as follows:

Years.	Bushels.	Value.	Years.	Bushels.	Value.
1870	6,727,597	$4,759,563	1882	12,182,722	$10,866,628
1871	4,866,700	3,678,810	1883	10,050,687	7,737,984
1872	5,565,591	3,403,607	1884	8,596,122	5,922,144
1873	4,244,751	2,962,981	1885	9,986,507	6,522,092
1874	4,891,189	5,801,653	1886	10,197,115	7,177,887
1875	6,255,063	6,297,738	1887	10,355,594	6,173,208
1876	10,285,957	7,887,886	1888	10,831,461	8,076,082
1877	6,702,965	5,099,326			
1878	6,764,228	4,105,748	Total	150,889,102	113,106,063
1879	5,720,979	5,402,680			
1880	7,135,258	4,537,921	Annual average	7,941,532	5,952,951
1881	9,528,616	6,692,125			

BUCKWHEAT.

This grain has the smallest area of all the cereals. About two-thirds of the crop is the product of two States, New York and Pennsylvania. It is mostly used in adjacent cities. It is only grown experimentally in the South, and in an extremely limited way in the West.

The record is as follows:

Years.	Total production.	Total area of crop.	Total value of crop.	Average value per bushel.	Average yield per acre.	Average value per acre.
	Bushels.	*Acres.*		*Cents.*	*Bushels.*	
1880	14,617,535	822,802	$8,682,488	59.4	17.7	$10.55
1881	9,486,200	828,815	8,205,705	86.5	11.4	9.90
1882	11,019,353	847,112	8,038,862	72.9	13.1	9.48
1883	7,668,954	857,349	6,303,980	82.2	8.9	7.35
1884	11,116,000	879,403	6,549,020	59.0	12.6	7.45
1885	12,626,000	914,394	7,057,363	55.9	13.8	7.72
1886	11,869,000	917,915	6,465,120	54.5	12.9	7.04
1887	10,844,000	910,506	6,122,320	56.5	11.9	6.72
Total	89,247,042	6,978,296	57,424,858			
Annual average	11,155,880	872,287	7,178,107	64.3	12.8	8.23
Annual average for preceding ten years	9,747,272	551,104	6,972,974	71.5	17.7	12.65

ALL CEREALS.

In this aggregate are included only the six cereals reported in the preceding pages. Rice has not hitherto been included in these statements, and will be separately mentioned. The supply for the previous decade averaged 42 bushels per head of population. In the period since 1879 the average has increased to 48 bushels, which is about three times the per capita consumption of Europe. It is proper to say that roots of various kinds are far less extensively used here than in Europe, and that corn enters far more generally into the rations of feeding animals in the absence of turnips, beets, and other vegetables. This is the result of climatic differences. It is nevertheless true that cereals are produced here in unparalleled abundance, and are fed profusely, even wastefully, in consequence. The average annual value of all cereals has increased from $987,857,142 to $1,284,477,973, and would make a much larger figure but for their reduction in price per bushel. They constitute a very important part of the products of American agriculture. The summary aggregate of these six cereals is as follows:

Calendar years.	Total production.	Total area of crops.	Total value of crops.
	Bushels.	*Acres.*	
1880	2,718,193,501	120,926,286	$1,361,497,704
1881	2,066,029,570	123,388,070	1,470,957,200
1882	2,699,394,496	126,568,539	1,468,693,393
1883	2,629,319,088	130,633,556	1,280,765,927
1884	2,992,880,000	136,292,766	1,184,311,520
1885	3,015,439,000	135,876,080	1,143,146,759
1886	2,842,579,000	141,859,656	1,162,161,910
1887	2,660,457,000	141,821,315	1,204,289,370
Total	21,624,291,655	1,057,366,268	10,275,823,783
Annual average	2,703,036,457	132,170,783	1,284,477,973
Annual average for preceding ten years	1,872,093,769	83,391,089	987,857,142

POTATOES.

The season of 1888 was more favorable for potatoes than any since 1884, when a heavy crop was produced. Three poor years have been succeeded by a fairly good season, and the general yield per acre, while not the largest known, is large enough to effectually show that neither the crop, the seed, nor the soil is running out in this country, as some have contended. Local droughts and other unfavorable meteorological conditions, which so seriously shortened the crops of 1886 and 1887, wrought little injury, and though growth was at no time unusually luxuriant or condition very high, it was remarkably even from the first to the last report, with a resulting medium yield of good quality. The range in reported condition was unusually small. Starting in with 95.7 in July, a figure lower than the average at that date for a series of years, the decline was slight and regular each month till October, the last report, when it stood at 86.8, a falling off of about nine points during the whole season. The loss during the same period in 1887 was three times as large.

The July report indicated an increase in the acreage of nearly 5 per cent., or 110,000 acres, the total area being approximately 2,460,000 acres. This increment was distributed over the whole country, only two States failing to record a part of it. It was heaviest of course in the newer States of the West, where population is rapidly increas-

ing from emigration, but it was also marked in the South Atlantic and Gulf States and in portions of the Ohio Valley. The returns of yield per acre, when consolidated, make an average for the whole country of slightly above 79 bushels, indicating a crop of not far from 196,000,000 bushels. The acreage, average yield per acre, and total product for eight years past are thus shown:

Calendar years.	Total production.	Total area of crop.	Total value of crop.	Average value per bushel.	Average yield per acre.	Average value of yield per acre.
	Bushels.	*Acres.*		*Cents.*	*Bushels.*	
1880	167,659,570	1,842,510	$81,062,214	48.3	91.0	$44.00
1881	109,145,494	2,041,670	99,291,341	90.9	53.5	48.63
1882	170,972,508	2,171,636	95,304,844	55.7	78.7	43.89
1883	208,164,425	2,289,275	87,849,991	42.2	91.0	38.37
1884	190,642,000	2,220,980	75,524,290	39.6	85.8	34.00
1885	175,029,000	2,265,823	78,153,403	44.7	77.2	34.49
1886	168,051,000	2,287,136	78,441,940	46.7	73.5	34.30
1887	134,103,000	2,357,322	91,506,740	68.2	56.9	38.82
Total	1,323,766,997	17,476,852	687,134,763			
Annual average	165,470,875	2,184,544	85,891,845	51.9	75.7	39.32
Annual average for preceding ten years	132,837,175	1,514,045	74,653,771	56.2	87.7	49.31

TOBACCO.

The tobacco crop of 1888 (which has not yet gone to market) is larger than that of the preceding one, which was one of the smallest grown for many years. The October average, the last monthly report of condition, was 85.7, against 73.8 in 1887. The acreage also was larger, from the stimulus of high prices caused by the previous concerted effort towards reduction generally, and especially of the Western acreage. There was a reduction in condition, as reported in October, for three successive years following 1884, when the average was 90.

The record of eight previous years, since the crop reported in the National Census, of area, product, and value, as estimated, is as follows:

Calendar years.	Total production.	Total area of crop.	Total value of crop.	Average value per pound.	Average yield per acre.	Average value of yield per acre.
	Pounds.	*Acres.*		*Cents.*	*Pounds.*	
1880	460,000,000	610,000	$39,100,000	8.5	754.1	$64.10
1881	450,880,014	646,239	43,372,000	9.6	697.7	67.11
1882	513,077,558	671,522	43,189,951	8.4	764.1	64.32
1883	451,545,641	638,739	40,455,362	9.0	706.9	63.34
1884	541,504,000	724,668	44,160,151	8.2	747.2	60.94
1885	562,736,000	752,520	43,265,598	7.7	747.8	57.49
1886	532,537,000	750,210	39,468,218	7.4	709.9	52.61
1887	386,240,000	598,620	40,977,259	10.6	645.2	68.45
Total	3,898,520,213	5,392,518	333,988,539			
Annual average	487,315,027	674,065	41,748,567	8.6	722.9	61.94
Annual average for preceding ten years	464,920,000	629,944	39,770,600	8.6	738.0	63.13

HAY.

The hay crop of 1888 was abundant in quantity and of medium quality. It was much larger than that of 1887. The yield was good in the

Atlantic States, except that in some counties in New York it was reduced by drought, and in parts of Virginia it was injured by rains after cutting. In Kentucky and Tennessee the crop was injured by drought. Elsewhere the yield was medium to large. In the South there was a large increase of area, and a promise of rapid enlargement in the future. There is a decided interest in stock improvement in this section which has formerly given less attention than other parts of the country to the improvement of farm animals. The records of previous years are as follows:

Calendar years.	Total production.	Total area of crop.	Total value of crop.	Average value per ton.	Average yield per acre.	Average value of yield per acre.
	Tons.	*Acres.*			*Tons.*	
1880	31,925,233	25,863,955	$371,811,084	$11.65	1.23	$14.38
1881	35,135,064	30,888,700	415,131,366	11.82	1.14	13.43
1882	38,138,049	32,339,585	369,958,158	9.70	1.18	11.44
1883	46,864,009	35,515,948	383,834,451	8.19	1.32	10.81
1884	48,470,460	38,571,593	396,139,309	8.17	1.26	10.27
1885	44,731,550	39,849,701	389,752,873	8.71	1.12	9.78
1886	41,796,499	36,501,688	353,437,699	8.46	1.15	9.68
1887	41,454,458	37,664,730	413,440,283	9.97	1.10	10.98
Total	328,515,322	277,195,909	3,093,505,223			
Annual average	41,084,415	34,649,489	386,688,153	9.41	1.19	11.16
Annual average for preceding ten years	28,526,750	23,142,841	323,935,991	11.36	1.23	14.00

CROP ESTIMATES FOR 1887.

Table showing the product of the cereals, potatoes, tobacco, hay, and cotton of the several States named, the yield per acre, the total acreage, the average price in each State, and the value of each crop for 1887.

States.	Products.	Quantity produced in 1887.	Average yield per acre.	Number of acres in each crop.	Value per unit of quantity.	Total valuation.
Maine	Indian corn...bushels	1,132,000	35.2	32,165	$0.68	$769,760
	Wheat ...do	481,000	12.2	39,460	1.05	505,050
	Rye ...do	30,000	12.3	2,433	.85	25,500
	Oats ...do	2,684,000	28.8	93,205	.42	1,127,280
	Barley ...do	239,000	21.3	11,206	.67	160,130
	Buckwheat ...do	380,000	18.0	21,132	.57	216,600
	Potatoes ...do	4,436,000	65	68,239	.69	3,060,840
	Hay ...tons	1,443,872	1.1	1,312,611	11.14	16,084,734
	Total			1,580,451		21,949,894
New Hampshire	Indian corn ...bushels	1,323,000	34.3	38,578	.69	912,870
	Wheat ...do	110,000	10.5	10,485	1.04	114,400
	Rye ...do	34,000	10.7	3,179	.84	28,560
	Oats ...do	965,000	28.6	33,749	.43	414,950
	Barley ...do	85,000	22.0	3,857	.69	58,650
	Buckwheat ...do	71,000	14.5	4,880	.56	39,760
	Potatoes ...do	1,216,000	42	28,956	.85	1,033,600
	Hay ...tons	754,069	1.1	685,517	10.50	7,917,725
	Total			809,201		10,520,515
Vermont	Indian corn ...bushels	2,204,000	35.5	62,091	.68	1,498,720
	Wheat ...do	320,000	15.0	21,351	.96	307,200
	Rye ...do	76,000	12.7	5,976	.69	52,440
	Oats ...do	2,736,000	25.4	107,723	.40	1,094,400
	Barley ...do	260,000	22.2	11,711	.65	169,000
	Buckwheat ...do	283,000	15.7	18,041	.55	155,650
	Potatoes ...do	2,258,000	60	37,632	.71	1,603,180
	Hay ...tons	1,252,225	1.2	1,043,521	9.54	11,946,227
	Total			1,308,046		16,826,817

Table showing the product of the cereals, potatoes, tobacco, hay, etc.—Continued.

States.	Products.	Quantity produced in 1887.	Average yield per acre.	Number of acres in each crop.	Value per unit of quantity.	Total valuation.
Massachusetts	Indian corn...bushels	2,124,000	35.4	59,997	$0.70	$1,486,800
	Wheat...do	16,000	14.8	1,080	1.00	16,000
	Rye...do	245,000	10.4	23,550	.74	181,300
	Oats...do	703,000	28.4	24,752	.43	302,290
	Barley...do	75,000	22.6	3,318	.73	54,750
	Buckwheat...do	77,000	14.3	5,387	.68	52,360
	Potatoes...do	2,350,000	66	35,608	.92	2,162,000
	Tobacco...pounds	3,511,000	1,425	2,464	.17	596,904
	Hay...tons	770,702	1.2	642,252	15.80	12,177,092
	Total	....	....	798,403	....	17,029,496
Rhode Island	Indian corn...bushels	414,000	32.0	12,946	.70	289,800
	Rye...do	14,000	10.4	1,345	.77	10,780
	Oats...do	165,000	26.0	6,353	.43	70,950
	Barley...do	19,000	22.6	840	.72	13,680
	Potatoes...do	522,000	78	6,688	.90	469,800
	Hay...tons	115,892	1.1	105,356	16.75	1,941,191
	Total	....	....	133,528	....	2,796,201
Connecticut	Indian corn...bushels	1,977,000	34.0	58,140	.67	1,324,590
	Wheat...do	37,000	17.0	2,171	.99	36,630
	Rye...do	353,000	12.0	29,381	.69	243,570
	Oats...do	1,088,000	27.0	39,417	.42	456,960
	Barley...do	14,000	21.9	638	.68	9,520
	Buckwheat...do	117,000	10.7	10,974	.64	74,880
	Potatoes...do	2,349,000	73	32,172	.90	2,114,100
	Tobacco...pounds	9,173,000	1,480	6,198	.143	1,311,745
	Hay...tons	632,114	1.1	574,649	14.70	9,292,076
	Total	....	....	753,740	....	14,864,071
New York	Indian corn...bushels	23,410,000	33.0	709,406	.57	$13,343,700
	Wheat...do	10,137,000	15.2	666,883	.82	8,312,340
	Rye...do	2,533,000	10.8	234,506	.61	1,545,130
	Oats...do	33,208,000	23.5	1,413,088	.37	12,286,960
	Barley...do	6,733,000	19.8	340,028	.68	4,578,440
	Buckwheat...do	4,130,000	13.0	317,663	.53	2,188,900
	Potatoes...do	23,327,000	66	353,433	.62	14,462,740
	Tobacco...pounds	7,623,000	1,320	5,775	.115	876,645
	Hay...tons	5,818,000	1.15	5,059,913	10.76	62,611,364
	Total	....	....	9,100,695	....	120,206,219
New Jersey	Indian corn...bushels	10,406,000	30.0	346,866	.55	5,723,300
	Wheat...do	1,459,000	10.2	143,083	.87	1,269,330
	Rye...do	994,000	9.6	103,518	.58	576,520
	Oats...do	3,221,000	23.2	138,830	.36	1,159,560
	Buckwheat...do	426,000	11.8	36,084	.59	251,340
	Potatoes...do	2,767,000	67	41,301	.73	2,019,910
	Hay...tons	616,989	1.25	493,591	12.64	7,798,741
	Total	....	....	1,303,273	....	18,798,701
Pennsylvania	Indian corn...bushels	44,905,000	32.2	1,394,561	.50	22,452,500
	Wheat...do	13,785,000	9.7	1,421,151	.81	11,165,850
	Rye...do	3,429,000	8.7	394,135	.56	1,920,240
	Oats...do	33,921,000	25.5	1,330,234	.35	11,872,350
	Barley...do	485,000	17.8	27,223	.68	329,800
	Buckwheat...do	3,266,000	11.9	274,445	.56	1,828,960
	Potatoes...do	10,676,000	55	194,105	.70	7,473,200
	Tobacco...pounds	40,213,000	1,430	28,121	.15	6,031,955
	Hay...tons	3,422,873	1.25	2,738,298	11.31	38,712,694
	Total	....	....	7,803,273	....	101,787,549
Delaware	Indian corn...bushels	4,332,000	20.0	216,595	.43	1,862,760
	Wheat...do	929,000	9.8	94,790	.84	780,360
	Rye...do	6,000	7.0	857	.56	3,360
	Oats...do	458,000	21.2	21,623	.33	151,140
	Potatoes...do	283,000	67	4,224	.53	149,990
	Hay...tons	66,820	1.2	55,683	12.00	801,840
	Total	....	....	393,772	....	3,749,450

Table showing the product of the cereals, potatoes, tobacco, hay, etc.—Continued.

States.	Products.	Quantity produced in 1887.	Average yield per acre.	Number of acres in each crop.	Value per unit of quantity.	Total valuation.
Maryland	Indian corn...bushels..	19,415,000	27.0	719,073	$0.45	8,736,750
	Wheat...do....	5,797,000	10.3	562,836	.83	4,811,510
	Rye...do....	265,000	8.7	30,443	.55	145,750
	Oats...do....	2,488,000	20.7	117,798	.33	804,540
	Buckwheat...do....	131,000	12.0	10,894	.54	70,740
	Potatoes...do....	1,323,000	63	20,904	.55	727,650
	Tobacco...pounds..	26,603,000	638	41,697	.055	1,463,148
	Hay...tons..	404,906	1.25	323,925	11.45	4,636,174
	Total	....	....	1,827,660	....	21,396,262
Virginia	Indian corn...bushels..	37,680,000	17.5	2,153,126	.47	17,709,600
	Wheat...do....	4,832,000	7.6	635,838	.81	3,913,920
	Rye...do....	337,000	6.5	51,840	.55	185,350
	Oats...do....	11,095,000	17.0	652,665	.35	3,883,250
	Barley...do....	20,000	17.0	1,174	.73	14,600
	Buckwheat...do....	198,000	8.6	23,035	.60	118,800
	Potatoes...do....	1,894,000	53	35,741	.61	1,155,340
	Tobacco...pounds..	79,408,000	600	132,346	.08	6,352,608
	Hay...tons..	434,663	1.20	362,219	10.24	4,450,949
	Cotton...pounds..	7,421,640	184	40,334	.086	638,261
	Total	....	....	4,088,318	....	38,422,678
North Carolina	Indian corn...bushels..	35,830,000	13.4	2,673,910	.59	21,139,700
	Wheat...do....	5,094,000	7.1	717,442	.88	4,482,720
	Rye...do....	395,000	5.8	68,173	.80	316,000
	Oats...do....	8,504,000	13.0	654,116	.44	3,741,760
	Barley...do....	3,000	10.5	287	.75	2,250
	Buckwheat...do....	57,000	8.0	7,088	.60	34,200
	Potatoes...do....	1,114,000	52	21,427	.59	657,260
	Tobacco...pounds..	29,155,000	485	60,113	.10	2,915,481
	Hay...tons..	159,750	1.15	138,913	10.57	1,688,558
	Cotton...pounds..	204,047,260	191	1,066,301	.087	17,752,112
	Total	....	....	5,407,770	....	52,730,041
South Carolina	Indian corn...bushels..	15,013,000	10.0	1,501,322	.62	9,308,060
	Wheat...do....	1,233,000	6.4	192,637	.99	1,220,670
	Rye...do....	45,000	5.3	8,451	.90	40,500
	Oats...do....	4,607,000	11.6	397,108	.59	2,718,130
	Potatoes...do....	212,000	51	4,148	.95	201,400
	Hay...tons..	35,400	1.18	30,000	11.75	415,950
	Cotton...pounds..	279,810,740	172	1,622,185	.087	24,343,534
	Total	....	....	3,755,941	....	38,248,244
Georgia	Indian corn...bushels..	32,067,000	11.0	2,915,140	.63	20,202,210
	Wheat...do....	2,522,000	6.6	382,094	.95	2,395,900
	Rye...do....	138,000	5.0	27,627	.90	124,200
	Oats...do....	7,044,000	11.5	612,561	.58	4,085,520
	Barley...do....	19,000	12.4	1,531	.77	14,630
	Potatoes...do....	486,000	52	9,355	.90	437,400
	Hay...tons..	47,520	1.2	39,600	14.92	708,998
	Cotton...pounds..	452,741,524	154	2,941,486	.087	39,388,513
	Total	....	....	6,929,394	....	67,357,371
Florida	Indian corn...bushels..	4,816,000	10.6	454,306	.71	3,419,360
	Oats...do....	761,000	14.5	52,496	.60	456,600
	Potatoes...do....	132,000	60	2,196	1.00	132,000
	Cotton...pounds..	21,271,896	81	262,616	.086	1,829,383
	Total	....	....	771,614	....	5,837,343
Alabama	Indian corn...bushels..	33,522,000	13.6	2,464,827	.54	18,101,880
	Wheat...do....	1,305,000	6.3	207,115	.98	1,278,900
	Rye...do....	33,000	5.2	6,362	.95	31,350
	Oats...do....	4,643,000	11.0	422,101	.58	2,692,940
	Potatoes...do....	553,000	58	9,541	.91	503,230
	Hay...tons..	47,554	1.18	40,300	14.40	684,778
	Cotton...pounds..	417,235,600	149	2,809,599	.086	35,881,402
	Total	....	....	5,959,845	....	59,174,480

Table showing the product of the cereals, potatoes, tobacco, hay, etc.—Continued.

States.	Products.	Quantity produced in 1887.	Average yield per acre.	Number of acres in each crop.	Value per unit of quantity.	Total valuation.
Mississippi	Indian corn...bushels	32,633,000	17.3	1,886,319	$0.53	17,295,490
	Wheat...do	313,000	7.5	41,770	.95	297,350
	Rye...do	8,000	6.6	1,220	.90	7,200
	Oats...do	4,410,000	12.3	358,551	.57	2,513,700
	Potatoes...do	475,000	55	8,642	.87	413,250
	Hay...tons	52,920	1.4	37,800	11.38	602,230
	Cotton...pounds	510,142,560	200	2,548,674	.086	43,872,260
	Total			4,882,976		65,001,480
Louisiana	Indian corn...bushels	18,022,000	18.0	1,001,226	.51	9,191,220
	Rye...do	7,000	5.5	1,275	.85	5,950
	Oats...do	498,000	13.5	36,861	.53	263,940
	Potatoes...do	381,000	55	6,930	.91	346,710
	Hay...tons	77,364	1.4	55,260	9.70	750,431
	Cotton...pounds	243,227,804	228	1,066,854	.086	20,917,591
	Total			2,168,406		31,475,842
Texas	Indian corn...bushels	76,490,000	17.0	4,499,405	.51	39,009,900
	Wheat...do	5,450,000	10.0	544,977	.80	4,360,000
	Rye...do	53,000	8.7	6,098	.70	37,100
	Oats...do	12,193,000	21.0	580,614	.37	4,511,410
	Barley...do	107,000	13.0	8,233	.56	59,920
	Potatoes...do	587,000	54	10,862	.92	540,040
	Hay...tons	171,640	1.3	132,031	10.00	1,716,400
	Cotton...pounds	801,570,286	202	3,960,327	.083	66,530,334
	Total			9,742,547		116,765,104
Arkansas	Indian corn...bushels	41,367,000	20.0	2,068,349	.50	20,683,500
	Wheat...do	2,290,000	9.9	231,357	.82	1,877,800
	Rye...do	39,000	8.5	4,582	.80	31,200
	Oats...do	4,710,000	17.5	269,125	.40	1,884,000
	Potatoes...do	758,000	60	12,638	.70	530,600
	Tobacco...pounds	1,228,000	520	2,361	.16	196,435
	Hay...tons	57,338	1.3	44,106	9.75	559,046
	Cotton...pounds	299,950,128	216	1,388,658	.085	25,495,761
	Total			4,021,176		51,258,342
Tennessee	Indian corn...bushels	75,204,000	21.5	3,497,848	.50	37,602,000
	Wheat...do	9,595,000	8.0	1,199,400	.77	7,388,150
	Rye...do	212,000	5.7	37,221	.71	150,520
	Oats...do	9,225,000	14.3	645,086	.38	3,505,500
	Barley...do	39,000	12.3	3,174	.57	22,230
	Buckwheat...do	41,000	7.4	5,515	.60	24,600
	Potatoes...do	1,966,000	50	39,326	.66	1,297,560
	Tobacco...pounds	26,254,000	575	45,659	.105	2,756,662
	Hay...tons	312,594	1.18	264,910	10.40	3,250,978
	Cotton...pounds	155,156,540	181	855,799	.085	13,188,306
	Total			6,593,938		69,186,506
West Virginia	Indian corn...bushels	12,516,000	19.0	658,755	.54	6,758,640
	Wheat...do	2,840,000	9.4	302,177	.76	2,158,400
	Rye...do	116,000	6.3	18,468	.60	69,600
	Oats...do	2,531,000	17.8	142,207	.35	885,850
	Barley...do	13,000	22.3	584	.55	7,150
	Buckwheat...do	298,000	7.5	39,724	.64	190,720
	Potatoes...do	1,422,000	51	27,885	.77	1,094,940
	Tobacco...pounds	2,216,000	560	3,958	.127	281,493
	Hay...tons	428,509	1.1	389,554	9.30	3,985,134
	Total			1,583,312		15,431,927
Kentucky	Indian corn...bushels	57,840,000	18.3	3,160,668	.53	30,655,200
	Wheat...do	11,113,000	10.2	1,089,493	.73	8,112,490
	Rye...do	860,000	9.4	91,480	.60	516,000
	Oats...do	8,847,000	18.0	491,496	.34	3,007,980
	Barley...do	247,000	18.3	13,500	.52	128,440
	Potatoes...do	2,297,000	45	51,051	.83	1,906,510
	Tobacco...pounds	115,896,000	590	196,434	.12	13,907,527
	Hay...tons	374,695	1.15	325,822	12.00	4,496,340
	Total			5,419,944		62,730,487

Table showing the product of the cereals, potatoes, tobacco, hay, etc.—Continued.

States.	Products.	Quantity produced in 1887.	Average yield per acre.	Number of acres in each crop.	Value per unit of quantity.	Total valuation.
Ohio	Indian corn...bushels	73,797,000	26.3	2,805,961	$0.48	$35,422,560
	Wheat...do	35,895,000	13.1	2,740,087	.75	26,921,250
	Rye...do	651,000	12.4	52,470	.58	377,580
	Oats...do	30,098,000	30.0	1,003,278	.32	9,631,360
	Barley...do	581,000	20.5	28,334	.68	395,080
	Buckwheat...do	107,000	9.7	11,079	.68	72,760
	Potatoes...do	4,707,000	30	156,904	.91	4,283,370
	Tobacco...pounds	19,240,000	615	31,284	.09	1,731,569
	Hay...tons	3,088,764	1.2	2,573,970	10.25	31,659,831
	Total	....	....	9,403,367	....	110,495,360
Michigan	Indian corn...bushels	18,930,000	22.5	841,316	.48	9,086,400
	Wheat...do	21,672,000	13.3	1,629,467	.74	16,037,280
	Rye...do	283,000	12.3	22,994	.55	155,650
	Oats...do	22,644,000	29.6	765,000	.32	7,246,080
	Barley...do	864,000	19.5	44,306	.69	596,160
	Buckwheat...do	394,000	12.3	32,073	.67	263,980
	Potatoes...do	4,485,000	30	149,499	.72	3,229,200
	Hay...tons	1,720,205	1.2	1,433,504	10.80	18,578,214
	Total	....	....	4,918,159	....	55,192,964
Indiana	Indian corn...bushels	71,400,000	20.0	3,569,994	.45	32,130,000
	Wheat...do	37,828,000	13.5	2,802,083	.72	27,236,160
	Rye...do	499,000	11.8	42,263	.54	269,460
	Oats...do	27,943,000	27.0	1,034,923	.29	8,103,470
	Barley...do	355,000	18.0	19,698	.65	230,750
	Buckwheat...do	68,000	8.2	8,312	.67	45,560
	Potatoes...do	3,169,000	33	96,034	.95	3,010,550
	Tobacco...pounds	3,718,000	440	8,450	.05	185,900
	Hay...tons	2,591,600	1.1	2,356,000	10.47	27,134,052
	Total	....	....	9,937,757	....	98,345,902
Illinois	Indian corn...bushels	141,080,000	19.2	7,347,915	.41	57,842,800
	Wheat...do	36,861,000	15.2	2,425,092	.70	25,802,700
	Rye...do	2,296,000	12.0	191,330	.49	1,125,040
	Oats...do	108,866,000	29.5	3,690,385	.27	29,393,820
	Barley...do	723,000	17.5	41,337	.55	397,650
	Buckwheat...do	51,000	9.8	5,220	.63	32,130
	Potatoes...do	4,643,000	33	140,691	.90	4,178,700
	Tobacco...pounds	1,494,000	450	3,320	.10	149,400
	Hay...tons	2,724,879	.8	3,406,099	10.29	28,039,005
	Total	....	....	17,251,389	....	146,961,245
Wisconsin	Indian corn...bushels	25,775,000	25.3	1,018,778	.42	10,825,500
	Wheat...do	13,063,000	10.3	1,268,208	.64	8,360,320
	Rye...do	2,212,000	12.2	181,308	.48	1,061,760
	Oats...do	34,855,000	24.2	1,440,299	.28	9,759,400
	Barley...do	6,055,000	18.5	327,289	.53	3,209,150
	Buckwheat...do	257,000	8.5	30,250	.57	146,490
	Potatoes...do	8,255,000	75	110,064	.76	6,273,800
	Tobacco...pounds	11,271,000	1,020	11,050	.11	1,239,810
	Hay...tons	1,399,849	.8	1,749,811	10.30	14,418,445
	Total	....	....	6,137,066	....	55,294,675
Minnesota	Indian corn...bushels	18,081,000	29.8	606,756	.37	6,689,970
	Wheat...do	36,299,000	11.6	3,129,208	.59	21,416,410
	Rye...do	162,000	10.0	16,200	.46	74,520
	Oats...do	40,636,000	30.0	1,354,532	.26	10,565,360
	Barley...do	7,308,000	19.3	378,629	.46	3,361,680
	Buckwheat...do	53,000	9.3	5,709	.55	29,150
	Potatoes...do	4,961,000	77	64,424	.56	2,778,160
	Hay...tons	593,280	1.2	494,400	6.04	3,583,411
	Total	....	....	6,049,858	....	48,498,661
Iowa	Indian corn...bushels	183,502,000	25.5	7,196,148	.35	64,225,700
	Wheat...do	26,837,000	10.0	2,683,676	.61	16,370,570
	Rye...do	1,381,000	12.7	108,736	.44	607,640
	Oats...do	74,382,000	30.5	2,438,746	.24	17,851,680
	Barley...do	4,388,000	19.0	230,946	.44	1,930,720
	Buckwheat...do	241,000	9.7	24,854	.67	161,470
	Potatoes...do	7,949,000	55	144,523	.62	4,928,380
	Hay...tons	3,060,338	.85	3,600,398	7.36	22,524,088
	Total	....	....	16,428,027	....	128,600,248

Table showing the product of the cereals, potatoes, tobacco, hay, etc.—Continued.

States.	Products.	Quantity produced in 1887.	Average yield per acre.	Number of acres in each crop.	Value per unit of quantity.	Total valuation.
Missouri	Indian corn...bushels	140,949,000	22.0	6,406,785	$0.37	$52,151,130
	Wheat...do	27,744,000	16.2	1,712,603	.62	17,201,280
	Rye...do	537,000	11.3	47,551	.45	241,650
	Oats...do	39,793,000	29.3	1,358,119	.26	10,346,180
	Barley...do	160,000	18.2	8,795	.50	80,000
	Buckwheat...do	69,000	9.6	7,214	.68	46,920
	Potatoes...do	5,030,000	60	83,833	.62	3,118,600
	Tobacco...pounds	6,421,000	500	12,842	.10	642,100
	Hay...tons	1,767,150	1.2	1,472,625	8.21	14,508,302
	Total	....	....	11,110,367	....	98,336,162
Kansas	Indian corn...bushels	76,547,000	14.6	5,242,979	.37	28,322,390
	Wheat...do	7,607,000	9.6	792,394	.61	4,640,270
	Rye...do	967,000	9.5	101,750	.44	425,480
	Oats...do	40,041,000	26.6	1,505,291	.29	11,611,890
	Barley...do	601,000	20.5	29,301	.43	258,430
	Buckwheat...do	21,000	9.8	2,142	.65	13,650
	Potatoes...do	6,427,000	59	108,934	.70	4,498,900
	Hay...tons	1,481,040	1.1	1,346,400	5.80	8,590,032
	Total	....	....	9,129,191	....	58,361,042
Nebraska	Indian corn...bushels	93,150,000	24.1	3,865,158	.30	27,945,000
	Wheat...do	16,585,000	10.1	1,642,127	.53	8,790,050
	Rye...do	891,000	10.8	82,480	.35	311,850
	Oats...do	25,365,000	27.5	922,369	.21	5,326,650
	Barley...do	3,076,000	17.7	173,809	.37	1,138,120
	Buckwheat...do	34,000	9.3	3,658	.61	20,740
	Potatoes...do	4,436,000	70	63,371	.58	2,572,880
	Hay...tons	1,209,600	1.2	1,008,000	4.23	5,116,608
	Total	....	....	7,760,972	....	51,221,898
California	Indian corn...bushels	4,703,000	30.0	156,752	.61	2,868,830
	Wheat...do	30,429,000	11.0	2,766,235	.74	22,517,460
	Rye...do	289,000	9.5	30,409	.80	231,200
	Oats...do	2,196,000	26.8	81,955	.58	1,273,680
	Barley...do	16,291,000	20.5	794,695	.52	8,471,320
	Potatoes...do	5,070,000	80	63,378	.57	2,889,900
	Hay...tons	1,509,268	1.3	1,160,975	11.50	17,356,582
	Total	....	....	5,054,399	....	55,608,972
Oregon	Indian corn...bushels	182,000	27.3	6,673	.64	116,480
	Wheat...do	16,100,000	17.5	920,026	.68	10,948,000
	Rye...do	20,000	14.5	1,379	.75	15,000
	Oats...do	5,547,000	27.3	203,183	.40	2,218,800
	Barley...do	761,000	21.2	35,890	.45	342,450
	Buckwheat...do	11,000	14.2	774	.55	6,050
	Potatoes...do	1,058,000	77	13,743	.52	550,160
	Hay...tons	655,988	1.4	468,563	11.00	7,215,868
	Total	....	....	1,650,231	....	21,412,808
Nevada	Indian corn...bushels	24,000	27.8	863	.62	14,880
	Wheat...do	111,000	19.9	5,570	.80	88,800
	Oats...do	196,000	24.9	7,858	.50	98,000
	Barley...do	524,000	22.5	23,272	.65	340,600
	Potatoes...do	521,000	110	4,733	.78	406,380
	Hay...tons	250,965	1.3	193,050	9.75	2,446,909
	Total	....	....	235,346	....	3,395,569
Colorado	Indian corn...bushels	938,000	30.0	31,267	.63	590,940
	Wheat...do	2,514,000	21.0	119,709	.75	1,885,500
	Rye...do	28,000	14.2	1,966	.78	21,840
	Oats...do	1,569,000	31.0	50,617	.45	706,050
	Barley...do	176,000	25.6	6,876	.62	109,120
	Potatoes...do	867,000	105	8,258	.56	485,520
	Hay...tons	179,400	1.2	149,500	10.75	1,928,550
	Total	....	....	368,193	....	5,727,520

Table showing the product of the cereals, potatoes, tobacco, hay, etc—Continued.

States.	Products.	Quantity produced in 1887.	Average yield per acre.	Number of acres in each crop.	Value per unit of quantity.	Total valuation.
Arizona	Indian corn . . . bushels	59,000	19.0	3,111	$0.65	$38,350
	Wheat . . . do	303,000	13.5	22,450	.82	248,460
	Barley . . . do	452,000	20.0	22,600	.60	271,200
	Potatoes . . . do	68,000	48	1,418	.52	35,360
	Hay . . . tons	41,769	1.3	32,130	11.00	459,459
	Total	. . . . . .	. . . . . .	81,704	. . . . . .	1,052,829
Dakota	Indian corn . . . bushels	20,992,000	33.0	636,120	.35	7,347,200
	Wheat . . . do	52,406,000	14.3	3,664,737	.52	27,251,120
	Rye . . . do	218,000	13.0	16,750	.43	93,740
	Oats . . . do	37,266,000	31.4	1,186,800	.25	9,316,500
	Barley . . . do	4,154,000	18.3	227,000	.40	1,661,600
	Buckwheat . . . do	63,000	14.5	4,350	.57	35,910
	Potatoes . . . do	5,209,000	105	49,608	.43	2,239,870
	Hay . . . tons	607,750	1.3	467,500	4.06	2,467,465
	Total	. . . . . .	. . . . . .	6,252,865	. . . . . .	50,413,405
Idaho	Indian corn . . . bushels	56,000	28.2	1,989	.60	33,600
	Wheat . . . do	1,120,000	17.5	64,015	.77	862,400
	Oats . . . do	1,095,000	30.0	36,509	.45	492,750
	Barley . . . do	408,000	28.7	14,211	.50	204,000
	Potatoes . . . do	460,000	102	4,505	.36	165,600
	Hay . . . tons	169,493	1.2	141,244	6.50	1,101,705
	Total	. . . . . .	. . . . . .	262,473	. . . . . .	2,860,055
Montana	Indian corn . . . bushels	25,000	27.5	908	.60	15,000
	Wheat . . . do	1,760,000	18.0	97,786	.76	1,337,600
	Oats . . . do	1,866,000	31.0	60,180	.45	839,700
	Barley . . . do	78,000	22.6	3,458	.56	43,680
	Potatoes . . . do	491,000	110	4,466	.64	314,240
	Hay . . . tons	236,009	1.3	181,545	13.50	3,186,122
	Total	. . . . . .	. . . . . .	348,343	. . . . . .	5,736,342
New Mexico	Indian corn . . . bushels	970,000	19.0	51,056	.72	698,400
	Wheat . . . do	1,221,000	15.0	81,372	.90	1,098,900
	Oats . . . do	362,000	23.5	15,389	.46	166,520
	Barley . . . do	62,000	18.4	3,369	.58	35,960
	Potatoes . . . do	74,000	71	1,050	.50	37,000
	Hay . . . tons	39,312	1.2	32,760	10.25	402,948
	Total	. . . . . .	. . . . . .	184,996	. . . . . .	2,439,728
Utah	Indian corn . . . bushels	285,000	21.6	13,197	.75	213,750
	Wheat . . . do	1,971,000	19.0	103,738	.61	1,202,310
	Rye . . . do	19,000	8.3	2,287	.47	8,930
	Oats . . . do	786,000	26.5	29,658	.43	337,980
	Barley . . . do	660,000	22.2	29,750	.58	382,800
	Potatoes . . . do	1,088,000	90	12,084	.36	391,680
	Hay . . . tons	194,762	1.2	162,302	6.90	1,343,858
	Total	. . . . . .	. . . . . .	353,016	. . . . . .	3,881,308
Washington	Indian corn . . . bushels	74,000	21.9	3,375	.67	49,580
	Wheat . . . do	8,345,000	18.0	463,610	.67	5,591,150
	Rye . . . do	18,000	12.4	1,454	.76	13,680
	Oats . . . do	3,369,000	37.0	91,045	.44	1,482,360
	Barley . . . do	777,000	25.0	31,080	.49	380,730
	Potatoes . . . do	1,218,000	107	11,381	.45	548,100
	Hay . . . tons	287,634	1.3	221,257	9.60	2,761,286
	Total	. . . . . .	. . . . . .	823,211	. . . . . .	10,826,886
Wyoming	Oats . . . do	88,000	30.1	2,921	.45	39,600
	Potatoes . . . do	133,000	100	1,332	.58	77,140
	Hay . . . tons	146,094	1.25	116,875	9.50	1,387,893
	Total	. . . . . .	. . . . . .	121,128	. . . . . .	1,504,633

Summary for each State, showing the product, area, and value of each crop for 1887.

States and Territories.	Corn.			Wheat.		
	Bushels.	Acres.	Value.	Bushels.	Acres.	Value.
Maine	1,132,000	32,165	$769,760	481,000	39,460	$505,050
New Hampshire	1,323,000	38,578	912,870	110,000	10,485	114,400
Vermont	2,204,000	62,091	1,498,720	320,000	21,351	307,200
Massachusetts	2,124,000	59,997	1,486,800	16,000	1,080	16,000
Rhode Island	414,000	12,946	289,800	....	....	....
Connecticut	1,977,000	58,140	1,324,590	37,000	2,171	36,630
New York	23,410,000	709,406	13,343,700	10,137,000	666,883	8,312,340
New Jersey	10,406,000	346,866	5,723,300	1,459,000	143,083	1,269,330
Pennsylvania	44,905,000	1,394,561	22,452,500	13,785,000	1,421,151	11,165,850
Delaware	4,332,000	216,595	1,862,760	929,000	94,790	780,360
Maryland	19,415,000	719,073	8,736,750	5,797,000	562,836	4,811,510
Virginia	37,680,000	2,153,126	17,709,600	4,832,000	635,838	3,913,920
North Carolina	35,830,000	2,673,910	21,139,700	5,094,000	717,442	4,482,720
South Carolina	15,013,000	1,501,322	9,308,060	1,233,000	192,637	1,220,670
Georgia	32,067,000	2,915,140	20,202,210	2,522,000	382,094	2,395,900
Florida	4,816,000	454,306	3,419,360	....	....	....
Alabama	33,522,000	2,464,827	18,101,880	1,305,000	207,115	1,278,900
Mississippi	32,033,000	1,886,319	17,295,490	313,000	41,770	297,350
Louisiana	18,022,000	1,001,226	9,191,220	....	....	....
Texas	76,490,000	4,499,405	39,009,900	5,450,000	544,977	4,360,000
Arkansas	41,367,000	2,068,349	20,683,500	2,290,000	231,357	1,877,800
Tennessee	75,204,000	3,497,848	37,602,000	9,595,000	1,199,400	7,888,150
West Virginia	12,516,000	658,755	6,758,640	2,840,000	302,177	2,158,400
Kentucky	57,840,000	3,160,668	30,655,200	11,113,000	1,089,493	8,112,490
Ohio	73,797,000	2,805,961	35,422,560	35,895,000	2,740,087	26,921,250
Michigan	18,930,000	841,316	9,086,400	21,672,000	1,629,467	16,037,280
Indiana	71,400,000	3,569,994	32,130,000	37,828,000	2,802,083	27,236,160
Illinois	141,080,000	7,347,915	57,842,800	36,861,000	2,425,092	25,802,700
Wisconsin	25,775,000	1,018,778	10,825,500	13,063,000	1,268,208	8,360,320
Minnesota	18,081,000	606,756	6,689,970	36,299,000	3,129,208	21,416,410
Iowa	183,502,000	7,196,148	64,225,700	26,837,000	2,683,676	16,370,570
Missouri	140,949,000	6,406,785	52,151,130	27,744,000	1,712,603	17,201,280
Kansas	76,547,000	5,242,979	28,322,390	7,607,000	792,394	4,640,270
Nebraska	93,150,000	3,865,158	27,945,000	16,585,000	1,642,127	8,790,050
California	4,703,000	156,752	2,868,830	30,429,000	2,766,235	22,517,460
Oregon	182,000	6,673	116,480	16,100,000	920,026	10,948,000
Nevada	24,000	863	14,880	111,000	5,570	88,800
Colorado	938,000	31,267	590,940	2,514,000	119,709	1,885,500
Arizona	59,000	3,111	38,350	303,000	22,450	248,460
Dakota	20,992,000	636,120	7,347,200	52,406,000	3,664,737	27,251,120
Idaho	56,000	1,989	33,600	1,120,000	64,015	862,400
Montana	25,000	908	15,000	1,760,000	97,786	1,337,600
New Mexico	970,000	51,056	698,400	1,221,000	81,372	1,098,900
Utah	285,000	13,197	213,750	1,971,000	103,738	1,202,310
Washington	74,000	3,375	49,580	8,345,000	463,610	5,591,150
Total	1,456,161,000	72,392,720	646,106,770	456,329,000	37,641,783	310,612,960

States and Territories.	Rye.			Oats.		
	Bushels.	Acres.	Value.	Bushels.	Acres.	Value.
Maine	30,000	2,433	$25,500	2,684,000	93,205	$1,127,280
New Hampshire	34,000	3,179	28,560	965,000	33,749	414,950
Vermont	76,000	5,976	52,440	2,736,000	107,723	1,094,400
Massachusetts	245,000	23,550	181,300	703,000	24,752	302,290
Rhode Island	14,000	1,345	10,780	165,000	6,353	70,950
Connecticut	353,000	29,381	243,570	1,088,000	39,417	456,960
New York	2,533,000	234,506	1,545,130	33,208,000	1,413,088	12,286,960
New Jersey	994,000	103,518	576,520	3,221,000	138,830	1,159,560
Pennsylvania	3,429,000	394,135	1,920,240	33,921,000	1,330,234	11,872,350
Delaware	6,000	857	3,360	458,000	21,623	151,140
Maryland	265,000	30,443	145,750	2,438,000	117,798	804,540
Virginia	337,000	51,840	185,350	11,095,000	652,665	3,883,250
North Carolina	395,000	68,173	316,000	8,504,000	654,116	3,741,760
South Carolina	45,000	8,451	40,500	4,607,000	397,198	2,718,130
Georgia	138,000	27,627	124,200	7,044,000	612,561	4,085,520
Florida	....	....	....	761,000	52,496	456,600
Alabama	33,000	6,362	31,350	4,643,000	422,101	2,692,940
Mississippi	8,000	1,220	7,200	4,410,000	358,551	2,513,700
Louisiana	7,000	1,275	5,950	498,000	36,861	263,940
Texas	53,000	6,098	37,100	12,193,000	580,614	4,511,410
Arkansas	39,000	4,582	31,200	4,710,000	269,125	1,884,000
Tennessee	212,000	37,221	150,520	9,225,000	645,086	3,505,500
West Virginia	116,000	18,468	69,600	2,531,000	142,207	885,850

Summary for each State, showing product, area, and value for 1887—Continued.

States and Territories.	Rye.			Oats.		
	Bushels.	Acres.	Value.	Bushels.	Acres.	Value.
Kentucky	860,000	91,480	$516,000	8,847,000	491,496	$3,007,980
Ohio	651,000	52,470	377,580	30,098,000	1,003,278	9,631,360
Michigan	283,000	22,994	155,650	22,644,000	765,000	7,246,080
Indiana	499,000	42,263	269,460	27,943,000	1,034,923	8,103,470
Illinois	2,296,000	191,330	1,125,040	108,866,000	3,690,385	29,393,820
Wisconsin	2,212,000	181,308	1,061,760	34,855,000	1,440,299	9,759,400
Minnesota	162,000	16,200	74,520	40,636,000	1,354,532	10,565,360
Iowa	1,381,000	108,736	607,640	74,382,000	2,438,746	17,851,680
Missouri	537,000	47,551	241,650	39,793,000	1,358,119	10,346,180
Kansas	967,000	101,750	425,480	40,041,000	1,505,291	11,611,890
Nebraska	891,000	82,480	311,850	25,365,000	922,369	5,326,650
California	289,000	30,409	231,200	2,196,000	81,955	1,273,680
Oregon	20,000	1,379	15,000	5,547,000	203,183	2,218,800
Nevada	......	......	......	196,000	7,858	98,000
Colorado	28,000	1,966	21,840	1,569,000	50,617	706,050
Dakota	218,000	16,750	93,740	37,266,000	1,186,800	9,316,500
Idaho	......	......	......	1,095,000	36,509	492,750
Montana	......	......	......	1,866,000	60,180	839,700
New Mexico	......	......	......	362,000	15,389	166,520
Utah	19,000	2,287	8,930	786,000	29,658	337,980
Washington	18,000	1,454	13,680	3,369,000	91,045	1,482,360
Wyoming	......	......	......	88,000	2,921	39,600
Total	20,693,000	2,053,447	11,283,140	659,618,000	25,920,906	200,699,790

States and Territories.	Barley.			Buckwheat.		
	Bushels.	Acres.	Value.	Bushels.	Acres.	Value.
Maine	239,000	11,206	$160,130	380,000	21,132	$216,600
New Hampshire	85,000	3,857	58,650	71,000	4,880	39,760
Vermont	260,000	11,711	169,000	283,000	18,041	155,630
Massachusetts	75,000	3,313	54,750	77,000	5,387	52,360
Rhode Island	19,000	840	13,680	......	......	......
Connecticut	14,000	638	9,520	117,000	10,974	74,880
New York	6,733,000	340,028	4,578,440	4,130,000	317,663	2,188,900
New Jersey	......	......	......	426,000	36,084	251,340
Pennsylvania	485,000	27,223	329,800	3,266,000	274,445	1,828,960
Delaware	......	......	......	......	......	......
Maryland	......	......	......	131,000	10,894	70,740
Virginia	20,000	1,174	14,600	198,000	23,035	118,800
North Carolina	3,000	287	2,250	57,000	7,088	34,200
South Carolina	......	......	......	......	......	......
Georgia	19,000	1,531	14,630	......	......	......
Florida	......	......	......	......	......	......
Alabama	......	......	......	......	......	......
Mississippi	......	......	......	......	......	......
Louisiana	......	......	......	......	......	......
Texas	107,000	3,233	59,920	......	......	......
Arkansas	......	......	......	......	......	......
Tennessee	39,000	3,174	22,230	41,000	5,515	24,600
West Virginia	13,000	584	7,150	298,000	39,724	190,720
Kentucky	247,000	13,500	128,440	......	......	......
Ohio	581,000	28,334	395,080	107,000	11,079	72,760
Michigan	864,000	44,306	596,160	394,000	32,073	263,980
Indiana	355,000	19,698	230,750	68,000	8,312	45,560
Illinois	723,000	41,337	397,650	51,000	5,220	32,130
Wisconsin	6,055,000	327,289	3,209,150	257,000	30,259	146,490
Minnesota	7,308,000	378,629	3,361,680	53,000	5,709	29,150
Iowa	4,388,000	230,946	1,930,720	241,000	24,854	161,470
Missouri	160,000	8,795	80,000	69,000	7,214	46,920
Kansas	601,000	20,301	258,430	21,000	2,142	13,650
Nebraska	3,076,000	173,809	1,138,120	34,000	3,658	20,740
California	16,291,000	794,695	8,471,320	......	......	......
Oregon	761,000	35,890	342,450	11,000	774	6,050
Nevada	524,000	23,272	340,600	......	......	......
Colorado	176,000	6,876	109,120	......	......	......
Arizona	452,000	22,600	271,200	......	......	......
Dakota	4,154,000	227,000	1,661,600	63,000	4,350	35,910
Idaho	408,000	14,211	204,000	......	......	......
Montana	78,000	3,458	43,680	......	......	......
New Mexico	62,000	3,369	35,960	......	......	......
Utah	660,000	29,750	382,800	......	......	......
Washington	777,000	31,089	380,730	......	......	......
Total	56,812,000	2,901,953	29,464,390	10,844,000	910,506	6,122,320

Summary for each State, showing product, area, and value for 1887—Continued.

States and Territories.	Potatoes.			Hay.		
	Bushels.	Acres.	Value.	Tons.	Acres.	Value.
Maine	4,436,000	68,239	$3,060,840	1,443,872	1,312,611	$16,084,734
New Hampshire	1,216,000	28,956	1,033,600	754,069	685,517	7,917,725
Vermont	2,258,000	37,632	1,603,180	1,252,225	1,043,521	11,946,227
Massachusetts	2,350,000	35,608	2,162,000	770,702	642,252	12,177,092
Rhode Island	522,000	6,688	469,800	115,892	105,356	1,941,191
Connecticut	2,349,000	32,172	2,114,100	632,114	574,649	9,292,076
New York	23,327,000	353,433	14,462,740	5,818,900	5,059,913	62,611,364
New Jersey	2,767,000	41,301	2,019,910	616,989	493,591	7,798,741
Pennsylvania	10,676,000	194,105	7,473,200	3,422,873	2,738,298	38,712,694
Delaware	283,000	4,224	149,990	66,820	55,683	801,840
Maryland	1,323,000	20,994	727,650	404,906	323,925	4,636,174
Virginia	1,894,000	35,741	1,155,340	434,663	362,219	4,450,949
North Carolina	1,114,000	21,427	657,260	159,750	138,913	1,688,558
South Carolina	212,000	4,148	201,400	35,400	30,000	415,950
Georgia	486,000	9,355	437,400	47,520	39,600	708,998
Florida	132,000	2,196	132,000	.....	.....	.....
Alabama	553,000	9,541	503,230	47,554	40,300	684,778
Mississippi	475,000	8,642	413,250	52,920	37,800	602,230
Louisiana	381,000	6,930	346,710	77,364	55,260	750,431
Texas	587,000	10,862	540,040	171,640	132,031	1,716,400
Arkansas	758,000	12,638	530,600	57,338	44,106	559,046
Tennessee	1,966,000	39,326	1,297,560	312,594	264,910	3,250,978
West Virginia	1,422,000	27,885	1,094,940	428,509	389,554	3,985,134
Kentucky	2,297,000	51,051	1,906,510	374,695	325,822	4,496,340
Ohio	4,707,000	156,904	4,283,370	3,088,764	2,573,970	31,659,831
Michigan	4,485,000	149,499	3,229,200	1,720,205	1,433,504	18,578,214
Indiana	3,169,000	96,034	3,010,550	2,591,600	2,356,000	27,134,052
Illinois	4,643,000	140,691	4,178,700	2,724,879	3,406,099	28,089,005
Wisconsin	8,255,000	110,064	6,273,800	1,399,849	1,749,811	14,418,445
Minnesota	4,961,000	64,424	2,778,160	593,280	494,400	3,583,411
Iowa	7,949,000	144,523	4,928,380	3,060,338	3,600,398	22,524,088
Missouri	5,080,000	83,833	3,118,600	1,767,150	1,472,625	14,508,302
Kansas	6,427,000	108,934	4,498,900	1,481,040	1,346,400	8,590,032
Nebraska	4,436,000	68,371	2,572,880	1,209,600	1,008,000	5,116,608
California	5,070,000	63,378	2,889,900	1,509,268	1,160,975	17,856,582
Oregon	1,058,000	13,743	550,160	655,988	468,563	7,215,868
Nevada	521,000	4,733	406,380	250,965	193,050	2,446,909
Colorado	867,000	8,258	485,520	179,400	149,500	1,928,550
Arizona	68,000	1,413	35,360	41,769	32,130	459,459
Dakota	5,209,000	49,608	2,239,870	607,750	467,500	2,467,465
Idaho	460,000	4,505	165,600	169,493	141,244	1,101,705
Montana	491,000	4,466	314,240	236,009	181,545	3,186,122
New Mexico	74,000	1,050	37,000	39,312	32,760	402,948
Utah	1,088,000	12,084	391,680	194,762	162,302	1,343,858
Washington	1,218,000	11,381	548,100	287,634	221,257	2,761,286
Wyoming	133,000	1,332	77,140	146,094	116,875	1,387,893
Total	134,103,000	2,357,322	91,506,740	41,454,458	37,664,739	413,440,283

States and Territories.	Tobacco.			Cotton.		
	Pounds.	Acres.	Value.	Bales.	Acres.	Value.
Massachusetts	3,511,000	2,464	$596,904	.....	.....	.....
Connecticut	9,173,000	6,198	1,311,745	.....	.....	.....
New York	7,623,000	5,775	876,645	.....	.....	.....
Pennsylvania	40,213,000	28,121	6,031,955	.....	.....	.....
Maryland	26,603,000	41,697	1,463,148	.....	.....	.....
Virginia	79,408,000	132,346	6,352,608	16,134	40,334	$638,261
North Carolina	29,155,000	60,113	2,915,481	443,581	1,066,801	17,752,112
South Carolina	.....	.....	.....	595,342	1,622,185	24,348,534
Georgia	.....	.....	.....	947,158	2,941,486	39,388,513
Florida	.....	.....	.....	66,179	262,016	1,829,383
Alabama	.....	.....	.....	842,880	2,809,599	35,881,402
Mississippi	.....	.....	.....	1,062,797	2,548,674	43,872,260
Louisiana	.....	.....	.....	504,622	1,066,854	20,917,591
Texas	.....	.....	.....	1,584,131	3,960,327	66,580,884
Arkansas	1,228,000	2,361	196,435	611,010	1,388,658	25,495,761
Tennessee	26,254,000	45,659	2,756,662	316,646	855,799	13,188,806
West Virginia	2,216,000	3,958	281,493	.....	.....	.....
Kentucky	115,896,000	196,434	13,907,527	.....	.....	.....
Ohio	19,240,000	31,284	1,731,569	.....	.....	.....
Indiana	3,718,000	8,450	185,900	.....	.....	.....
Illinois	1,494,000	3,320	149,400	.....	.....	.....
Wisconsin	11,271,000	11,050	1,239,810	.....	.....	.....
Missouri	6,421,000	12,842	642,100	29,729	78,234	1,207,889
All other States and Territories, including Missouri for cotton	2,816,000	6,548	837,877			
Total	386,240,000	598,620	40,977,259	7,020,209	18,641,067	291,045,346

Table showing the average yield per acre and price per bushel, pound, or ton of farm products for the year 1887.

States and Territories.	Corn.		Wheat.		Rye.		Oats.		Barley.	
	Bushels.	Price per bushel.	Bushels.	Price per bushel.	Bushels.	Price per bushel.	Bushels.	Price per bushel.	Bushels.	Price per bushel.
Maine	35.2	$0.68	12.2	$1.05	12.3	$0.85	28.8	$0.42	21.3	$0.67
New Hampshire	34.3	.69	10.5	1.04	10.7	.84	28.6	.43	22.0	.69
Vermont	35.5	.68	15.0	.96	12.7	.69	25.4	.40	22.2	.65
Massachusetts	35.4	.70	14.8	1.00	10.4	.74	28.4	.43	22.6	.73
Rhode Island	32.0	.70	...	...	10.4	.77	26.0	.43	22.6	.72
Connecticut	34.0	.67	17.0	.99	12.0	.69	27.6	.42	21.9	.68
New York	33.0	.57	15.2	.82	10.8	.61	23.5	.37	19.8	.68
New Jersey	30.0	.55	10.2	.87	9.6	.58	23.2	.36	...	...
Pennsylvania	32.2	.50	9.7	.81	8.7	.56	25.5	.35	17.8	.68
Delaware	20.0	.43	9.8	.84	7.0	.56	21.2	.33	...	...
Maryland	27.0	.45	10.3	.83	8.7	.55	20.7	.33	...	...
Virginia	17.5	.47	7.6	.81	6.5	.55	17.0	.35	17.0	.73
North Carolina	13.4	.59	7.1	.88	5.8	.80	13.0	.44	10.5	.75
South Carolina	10.0	.62	6.4	.99	5.3	.90	11.6	.59	...	...
Georgia	11.0	.63	6.6	.95	5.0	.90	11.5	.56	12.4	.77
Florida	10.6	.71	...	...	...	...	14.5	.60	...	...
Alabama	13.6	.54	6.3	.98	5.2	.95	11.0	.58	...	...
Mississippi	17.3	.53	7.5	.95	6.6	.90	12.3	.57	...	...
Louisiana	18.0	.51	...	...	5.5	.85	13.5	.53	...	...
Texas	17.0	.51	10.0	.80	8.7	.70	21.0	.37	13.0	.56
Arkansas	20.0	.50	9.9	.82	8.5	.80	17.5	.40	...	...
Tennessee	21.5	.50	8.0	.77	5.7	.71	14.3	.38	12.8	.57
West Virginia	19.0	.54	9.4	.76	6.3	.60	17.8	.35	22.8	.55
Kentucky	18.3	.53	10.2	.73	9.4	.60	18.0	.34	18.3	.52
Ohio	26.3	.48	13.1	.75	12.4	.58	30.0	.32	20.5	.68
Michigan	22.5	.48	13.3	.74	12.3	.55	29.6	.32	19.5	.69
Indiana	20.0	.45	13.5	.72	11.8	.54	27.0	.29	18.0	.65
Illinois	19.2	.41	15.2	.70	12.0	.49	29.5	.27	17.5	.55
Wisconsin	25.3	.42	10.3	.64	12.2	.48	24.2	.28	18.5	.53
Minnesota	29.8	.37	11.6	.59	10.0	.46	30.0	.26	19.3	.46
Iowa	25.5	.35	10.0	.61	12.7	.44	30.5	.24	19.0	.44
Missouri	22.0	.37	16.2	.62	11.3	.45	29.3	.26	18.2	.50
Kansas	14.6	.37	9.6	.61	9.5	.44	26.6	.29	20.5	.43
Nebraska	24.1	.30	10.1	.53	10.8	.35	27.5	.21	17.7	.37
California	30.0	.61	11.0	.74	9.5	.80	26.8	.58	20.5	.52
Oregon	27.3	.64	17.5	.68	14.5	.75	27.3	.40	21.2	.45
Nevada	27.8	.62	19.9	.80	...	...	24.9	.50	22.5	.65
Colorado	30.0	.63	21.0	.75	14.2	.78	31.0	.45	25.6	.62
Arizona	19.0	.65	13.5	.82	...	...	...	...	20.0	.60
Dakota	33.0	.35	14.3	.52	13.0	.43	31.4	.25	18.3	.40
Idaho	28.2	.60	17.5	.77	...	...	30.0	.45	28.7	.50
Montana	27.5	.60	18.0	.76	...	...	31.0	.45	22.6	.56
New Mexico	19.0	.72	15.0	.90	...	...	23.5	.46	18.4	.58
Utah	21.6	.75	19.0	.61	8.3	.47	26.5	.43	22.2	.58
Washington	21.9	.67	18.0	.67	12.4	.76	37.0	.44	25.0	.49
Wyoming	...	...	...	...	...	...	30.1	.45	...	...
Average	20.1	.444	12.1	.681	10.1	.545	25.4	.304	19.6	.519

States and Territories.	Buckwheat.		Potatoes.		Hay.		Tobacco.		Cotton.		
	Bushels.	Price per bushel.	Bushels.	Price per bushel.	Tons.	Price per ton.	Pounds.	Price per pound.	Bales.	Pounds.	Price per pound.
Maine	18.0	$0.57	65	$0.69	1.1	$11.14	...	...	...	...	...
New Hampshire	14.5	.56	42	.85	1.1	10.50	...	...	...	...	...
Vermont	15.7	.55	60	.71	1.2	9.54	...	...	...	...	...
Massachusetts	14.3	.68	66	.92	1.2	15.80	1,425	$0.17	...	...	...
Rhode Island	...	...	78	.90	1.1	16.75	...	...	...	...	...
Connecticut	10.7	.64	73	.90	1.1	14.70	1,480	.143	...	...	...
New York	13.0	.53	66	.62	1.15	10.76	1,320	.115	...	...	...
New Jersey	11.8	.59	67	.73	1.25	12.64	...	...	...	...	...
Pennsylvania	11.9	.56	55	.70	1.25	11.31	1,430	.15	...	...	...
Delaware	...	...	67	.53	1.2	12.00	...	...	...	...	...
Maryland	12.0	.54	63	.55	1.25	11.45	638	.055	...	...	...
Virginia	8.6	.60	53	.61	1.20	10.24	600	.08	.40	184	$0.086
North Carolina	8.0	.60	52	.59	1.15	10.57	485	.10	.416	191	.087
South Carolina	...	...	51	.95	1.18	11.75	...	...	.367	172	.087
Georgia	...	...	52	.90	1.2	14.92	...	...	.322	154	.087
Florida	...	...	60	1.00	...	...	...	...	.252	81	.086
Alabama	...	...	58	.91	1.18	14.40	...	...	.30	149	.086

Table showing the average yield, etc., of farm products for the year 1887—Continued.

States and Territories.	Buckwheat.		Potatoes.		Hay.		Tobacco.		Cotton.		
	Bushels.	Price per bushel.	Bushels.	Price per bushel.	Tons.	Price per ton.	Pounds.	Price per pound.	Bales.	Pounds.	Price per pound.
Mississippi	...	...	55	$0.87	1.4	$11.38	...	...	.417	200	$0.086
Louisiana	...	...	55	.91	1.4	9.70	...	...	.473	228	.086
Texas	...	...	54	.92	1.3	10.00	...	...	.40	202	.083
Arkansas	...	...	60	.70	1.3	9.75	520	$0.16	.44	216	.085
Tennessee	7.4	$0.60	50	.66	1.18	10.40	575	.105	.37	181	.085
West Virginia	7.5	.64	51	.77	1.1	9.30	560	.127			
Kentucky	...	...	45	.83	1.15	12.00	590	.12			
Ohio	9.7	.68	30	.91	1.2	10.25	615	.09			
Michigan	12.3	.67	30	.72	1.2	10.80	...	...			
Indiana	8.2	.67	33	.95	1.1	10.47	440	.05			
Illinois	9.8	.63	33	.90	.8	10.29	450	.10			
Wisconsin	8.5	.57	75	.76	.8	10.30	1,020	.11			
Minnesota	9.3	.55	77	.56	1.2	6.04	...	...			
Iowa	9.7	.67	55	.62	.85	7.36	...	...			
Missouri	9.6	.68	60	.62	1.2	8.21	500	.10			
Kansas	9.8	.65	59	.70	1.1	5.80					
Nebraska	9.3	.61	70	.58	1.2	4.23					
California	...	...	80	.57	1.3	11.50			.38	182	.085
Oregon	14.2	.55	77	.52	1.4	11.00					
Nevada	...	...	110	.78	1.3	9.75					
Colorado	...	...	105	.56	1.2	10.75					
Arizona	...	...	48	.52	1.3	11.00					
Dakota	14.5	.57	105	.43	1.3	4.06	430	.12			
Idaho	...	...	102	.36	1.2	6.50					
Montana	...	...	110	.64	1.3	13.50					
New Mexico	...	...	71	.50	1.2	10.25					
Utah	...	...	90	.36	1.2	6.90					
Washington	...	...	107	.45	1.3	9.60					
Wyoming	...	...	100	.58	1.25	9.50					
Average	11.9	.565	56.9	.682	1.10	9.97	645.2	.106	.377	183	.085

Table showing the average cash value per acre of farm products for the year 1887.

States and Territories.	Corn.	Wheat.	Rye.	Oats.	Barley.	Buckwheat.	Potatoes.	Hay.	Tobacco.	Cotton.
Maine	$23.93	$12.80	$10.48	$12.09	$14.29	$10.25	$44.85	$12.25	...	...
New Hampshire	23.66	10.91	8.98	12.30	15.21	8.15	35.70	11.55	...	...
Vermont	24.14	14.39	8.78	10.16	14.43	8.63	42.60	11.45	...	...
Massachusetts	24.78	14.81	7.70	12.21	16.53	9.72	60.72	18.96	$242.25	...
Rhode Island	22.39	...	8.01	11.17	16.29	...	70.25	18.43	...	...
Connecticut	22.78	16.87	8.29	11.59	14.92	6.82	65.71	16.17	211.64	...
New York	18.81	12.46	6.59	8.70	13.46	6.89	40.92	12.37	151.80	...
New Jersey	16.50	8.87	5.57	8.35	...	6.97	48.91	15.80	...	...
Pennsylvania	16.10	7.86	4.87	8.93	12.11	6.66	38.50	14.14	214.50	...
Delaware	8.60	8.23	3.92	6.99	...	...	35.51	14.40	...	...
Maryland	12.15	8.55	4.79	6.83	...	6.49	34.66	14.31	35.09	...
Virginia	8.23	6.16	3.58	5.95	12.44	5.16	32.33	12.29	48.00	$15.82
North Carolina	7.91	6.25	4.64	5.72	7.84	4.83	30.67	12.16	48.50	16.65
South Carolina	6.20	6.34	4.79	6.84	...	...	48.55	13.87	...	15.01
Georgia	6.93	6.27	4.50	6.67	9.56	...	46.76	17.90	...	13.39
Florida	7.53	...	...	8.70	...	...	60.11	...	...	6.97
Alabama	7.34	6.17	4.93	6.38	...	...	52.74	16.99	...	12.77
Mississippi	9.17	7.12	5.90	7.01	...	...	47.82	15.93	...	17.21
Louisiana	9.18	...	4.67	7.16	...	...	50.03	13.58	...	19.61
Texas	8.67	8.00	6.08	7.77	7.28	...	49.72	13.00	...	16.80
Arkansas	10.00	8.12	6.81	7.00	...	...	41.98	12.68	83.20	18.36
Tennessee	10.75	6.16	4.04	5.43	7.00	4.46	32.99	12.27	60.37	15.41
West Virginia	10.26	7.14	3.77	6.23	12.24	4.80	39.27	10.23	71.12	
Kentucky	9.70	7.45	5.64	6.12	9.51	...	37.35	13.80	70.80	
Ohio	12.62	9.82	7.20	9.60	13.94	6.57	27.30	12.30	55.35	
Michigan	10.80	9.84	6.77	9.47	13.46	8.23	21.60	12.96	...	
Indiana	9.00	9.72	6.38	7.83	11.71	5.48	31.35	11.52	22.00	
Illinois	7.87	10.64	5.88	7.96	9.62	6.16	29.70	8.23	45.00	
Wisconsin	10.63	6.59	5.86	6.78	9.81	4.84	57.00	8.24	112.20	
Minnesota	11.03	6.84	4.60	7.80	8.88	5.11	43.12	7.25	...	
Iowa	8.93	6.10	5.59	7.32	8.36	6.50	34.10	6.26	...	
Missouri	8.14	10.04	5.08	7.62	9.10	6.50	37.20	9.85	50.00	
Kansas	5.40	5.86	4.18	7.71	8.82	6.37	41.30	6.38		
Nebraska	7.23	5.35	3.78	5.77	6.55	5.67	40.60	5.08		15.44
California	18.30	8.14	7.60	15.54	10.66	...	45.60	14.95		
Oregon	17.46	11.90	10.88	10.92	9.54	7.82	40.03	15.40		

Table showing average cash value per acre of farm products for 1887.—Continued.

States and Territories.	Corn.	Wheat.	Rye.	Oats.	Barley.	Buckwheat.	Potatoes.	Hay.	Tobacco.	Cotton.
Nevada	$17.24	$15.94	....	$12.47	$14.64	....	$85.86	$12.68		
Colorado	18.90	15.75	$11.11	13.95	15.87	....	58.79	12.90		
Arizona	12.33	11.07	....	....	12.00	....	25.02	14.30		
Dakota	11.55	7.44	5.60	7.85	7.32	$8.26	45.15	5.28	$51.60	
Idaho	16.89	13.47	....	13.50	14.36	....	36.76	7.80		
Montana	16.52	13.68	....	13.95	12.63	....	70.36	17.55		
New Mexico	13.68	13.50	....	10.82	10.67	....	35.24	12.30		
Utah	16.20	11.59	3.90	11.40	12.87	....	32.41	8.28		
Washington	14.69	12.06	9.41	16.28	12.25	....	48.16	12.48		
Wyoming	....	....	....	13.56	....	....	57.91	11.88		
General average.	8.93	8.25	5.49	7.74	10.15	6.72	38.82	10.98	68.45	15.61

General summary showing the estimated quantities, number of acres, and aggregate value of the crops of the farm in 1887.

Products.	Quantity produced.	Number of acres.	Value.
Indian corn .... bushels..	1,456,161,000	72,392,720	$646,106,770
Wheat .... do....	456,329,000	37,641,783	310,612,960
Rye .... do....	20,693,000	2,053,447	11,283,140
Oats .... do....	659,618,000	25,920,906	200,699,790
Barley .... do....	56,812,000	2,901,953	29,464,390
Buckwheat .... do....	10,844,000	910,506	6,122,320
Potatoes .... do....	134,103,000	2,357,322	91,506,740
Total	....	144,178,637	1,295,796,110
Tobacco .... pounds..	386,240,000	598,620	40,977,259
Hay .... tons..	41,454,458	37,664,739	413,440,283
Cotton .... bales..	7,020,209	18,641,067	291,045,346
Grand total	....	201,083,063	2,041,258,998

Table showing the average yield and cash value per acre, and price per unit of quantity of farm products for the year 1887.

Products.	Average yield per acre.	Average price per unit of quantity.	Average value per acre.	Products.	Average yield per acre.	Average price per unit of quantity.	Average value per acre.
Indian corn ..... bushels..	20.1	$0.444	$8.93	Buckwheat.... bushels..	11.9	$0.565	$6.72
Wheat .... do....	12.1	.681	8.25	Potatoes........ do....	56.9	.682	38.82
Rye .... do....	10.1	.545	5.49	Tobacco ...... pounds..	645.2	.106	68.45
Oats .... do....	25.4	.304	7.74	Hay ...... tons..	1.10	9.97	10.98
Barley .... do....	19.6	.519	10.15	Cotton........ pounds..	183	.085	15.61

FARM ANIMALS.

NUMBERS.

The tendency to increased attention to horse-breeding which has been so noticeable in recent years is still progressive. The low value of cattle stimulates renewed attention to horses. Improvement in quality is quite as apparent as increase of numbers. The popularity of the large French and English breeds is unabated. Enlarged demand for draught horses, locally, is caused by activity in railroad building. It is gratifying to notice that in some parts of the South, where manufacturing has been introduced or extended, there has arisen an unaccustomed demand for horses. In the Territories the establishment of horse ranches has increased the numbers of these useful animals. They are found to be thrifty and profitable stock for the range. They are not exempt, however, from losses and disabilities, as there are local complaints of the depredations of wolves and mountain lions, which prey upon the young colts. In some portions of the Western wheat area there has been diversion from cereals to farm animals, but especially to horses, as the local demand is great in rapidly-settling districts. On the other hand, they are in less demand in certain localities in the Ohio Valley which are reducing arable area and enlarging permanent pasture or other grass lands. Then, there are counties in which a plethora exits because buyers have not been sufficiently active in their purchases.

The total increase in numbers appears to be nearly half a million. The heaviest ratios of increase appear in the Territories and in Texas, Kansas, and Nebraska.

There has been a slight increase in mules. The cotton belt has never done much in raising either mules or horses. Some correspondents report efforts there in this direction. In Georgia the increase in Bermuda grass is made subservient to stock-growing, and especialy to mule-raising. Others report that mules can be grown on winter pasture and in the canebrakes about as easily as cattle.

The number of milch cows are gradually increasing with the advance of population. Milk and its products are found to be the cheapest as well as the most assimilable and nutritious of the foods, and there is no probability of a decline in the demand. The largest increase is in the Southwest and Northwest, where settlement is active and population increasing. The apparent increase of the year is 442,211.

The numbers in cattle of all kinds exceed the estimate of last year by more than a million. The increase is rapid in all the States where farm extension is in progress, as in the newer Western States and in Texas, Arkansas, and Tennessee. There is much dissatisfaction with the low price of cattle, which has tended to reduction in some places, and in others holding for better prices has tended to enlargement of numbers. There is much local complaint of combination of dealers and butchers to control prices, and of the discrimination of railroad companies in freight rates. There is some improvement in the quality of cattle, as reported in many Southern localities. It is a hopeful sign, indicating a greater popularity of cattle-growing, and leading ultimately to increase of numbers.

There appears to be a slight further reduction in numbers of sheep, due to discouragement at the low price of wool. It is gratifying to

observe evidences of re-assurance in the future of sheep husbandry, which may effect an increase of numbers hereafter. In some sections a slight increase is already perceptible.

In the numbers of swine there is a marked increase, ample for a meat supply of the natural increase of population, and to aid in the consumption of the large corn crop of the past year. But a portion of the increase is only apparent, as in several States a revision of previous estimates has enlarged the State aggregates. The tendency of current State statistics, founded on assessors' returns, which omit all the pigs under six months old, and often a considerable portion of the hogs, is to an underestimate of the numbers of swine, and this naturally affects the judgment of our correspondents.

The aggregate numbers of the different species of farm animals on farms and ranches, but not including those held in towns and cities, are as follows:

Stock.	1888.	1889.	Increase or decrease.
Horses	13,172,936	13,663,294	+ 490,358
Mules	2,191,727	2,257,574	+ 65,847
Milch cows	14,856,414	15,298,625	+ 442,211
Oxen and other cattle	34,378,363	35,032,417	+ 654,054
Sheep	43,544,755	42,599,079	− 495,676
Swine	44,346,525	50,301,592	+5,955,067

VALUES.

The values of farm animals, as reported by correspondents, are but little changed from the returns of January, 1888, horses and sheep advancing slightly, hogs more noticeably, while cattle and mules have declined somewhat.

Milch cows have declined 71 cents per head, but the increase in numbers is sufficient to almost entirely offset this shrinkage, leaving the aggregate value less than one-tenth of 1 per cent. smaller than at the preceding return.

In the case of oxen and other cattle the increase in numbers is not sufficient to make up for the decreased value per head, and the aggregate value is $14,513,708 less than the value of the same class of stock in 1888.

Sheep alone, of all farm animals, show a decline in number, but the advance of 8 cents per head is sufficient to increase the aggregate value of a year ago by more than $1,350,000. The value of this class of stock declined steadily from 1881 to 1886, when the turning point was reached and an advance began, which still continues. The falling off in numbers began three years later, and still continues.

Mules show a slight decline in price, but the total value exceeds that of 1888 by nearly $5,000,000. For four years past the changes in prices have been very slight, the extreme range between 1886 and 1889 amounting to only 87 cents.

A bountiful corn harvest, with a fairly healthful season for swine, has caused a large increase in the numbers of hogs, while the scarcity of this class of stock during the past two years has materially stiffened prices. The net aggregate increase of values of all classes of stock over 1888 amounts to $98,006,640, and of this increase swine furnishes over $70,000,000.

The following statement shows the total value of each class of stock on January 1, 1889, as compared with the same date in 1888, with the increase or decrease during the period:

Stock.	1888.	1889.	Increase or decrease.
Horses	$946,096,154	$982,194,827	+$36,098,673
Mules	174,853,563	179,444,481	+ 4,590,918
Milch cows	366,252,173	366,226,376	− 25,797
Oxen and other cattle	611,750,520	597,236,812	− 14,513,708
Sheep	89,279,926	90,640,369	+ 1,360,443
Swine	220,811,082	291,307,193	+ 70,496,111
Total	2,409,043,418	2,507,050,058	+ 98,006,640

In connection with the foregoing statement the following table, showing the average value per head of each class at the same dates, is presented:

Stock.	1888.	1889.	Increase or decrease.
Horses	$71.82	$71.89	+$0.07
Mules	79.78	79.49	− .29
Milch cows	24.65	23.94	− .71
Oxen and other cattle	17.79	17.05	− .74
Sheep	2.05	2.13	+ .08
Swine	4.98	5.79	+ .81

During the past ten years, or from 1880 to 1889, inclusive, the changes in the relative values of the different classes of stock have been very marked. At the beginning of that period horses averaged $54.75 per head, and they have since advanced, almost steadily, to $71,89, an increase of 31 per cent. Mules have almost equaled this showing, the price per head advancing from $61.26 to $79.49, or nearly 30 per cent. In the case of milch cows values have been more stable, the fluctuations from year to year, as a rule, not amounting to more than $2 per head, while between the first and last years of the period named the advance has amounted to only 67 cents, or from $23.27 to $23.94. Oxen and other cattle show a more decided advance than do cows, the average value in 1889 standing at $17.05 against $16.10 ten years before, an increase of 6 per cent. Sheep alone show a decline in value during the period, beginning with $2.21 per head and averaging now but $2.13, or a decline of nearly 4 per cent. The numbers of swine fluctuate considerably from year to year, more than any other class of animals, from the fact that they early reach maturity, enabling breeders to quickly meet any extra demand by an increase of numbers, or to send a present surplus to butchers without impairing the future supply. This easy expansion or contraction of herds makes a comparison of prices at two periods less fair than in the case of other stock. Changes in average value occur quicker and are more marked, perhaps fluctuating widely between the dates chosen. In 1880 the average was returned at $4.28 against $5.79 at the present date, an advance of 35 per cent., though during the period the value reached both a lower and a much higher point.

The accompanying statement of values yearly, from 1880 to 1889, will show the annual changes during the period under consideration:

Years.	Horses.	Mules.	Milch cows.	Other cattle.	Sheep.	Swine.
1880	$54.75	$61.26	$23.27	$16.10	$2.21	$4.28
1881	58.44	69.79	23.95	17.33	2.39	4.70
1882	58.52	71.35	25.89	19.89	2.37	5.98
1883	70.59	79.49	30.21	21.80	2.53	6.75
1884	74.64	84.22	31.37	23.52	2.37	5.57
1885	73.70	82.38	29.70	23.25	2.14	5.02
1886	71.27	79.60	27.40	21.17	1.91	4.25
1887	72.15	78.91	26.08	19.79	2.01	4.48
1888	71.82	79.78	24.65	17.79	2.05	4.98
1889	71.89	79.49	23.94	17.05	2.13	5.79

Table showing the estimated numbers of animals on farms and ranches, expressed as a percentage of the numbers of previous years; also average of actual prices January 1, 1889.

States and Territories.	Horses.					Mules.					Milch cows.	
	Total number compared with that of January, 1888.	Average price per head.				Total number compared with that of January, 1888.	Average price per head.				Total number compared with that of January, 1888.	Average price per head.
		Under one year old.	Between one and two years old.	Between two and three years old.	Over three years old.		Under one year old.	Between one and two years old.	Between two and three years old.	Over three years old.		
	P.ct.					*P.ct.*					*P.ct.*	
Maine	102	$36.28	$57.50	$80.56	$112.75	.....	.....	.....	.....	.....	104	$28.00
New Hampshire	102	34.17	54.17	76.69	105.50	.....	.....	.....	.....	.....	101	29.63
Vermont	102.5	33.50	53.63	75.63	105.63	.....	.....	.....	.....	.....	103	26.20
Massachusetts	102	36.88	62.88	86.25	115.25	.....	.....	.....	.....	.....	102	33.50
Rhode Island	101	42.50	78.75	103.75	117.00	.....	.....	.....	.....	.....	102	33.00
Connecticut	102	41.75	68.42	90.83	113.52	.....	.....	.....	.....	.....	103	34.50
New York	101	36.00	66.00	87.50	112.00	101.5	$36.70	$56.30	$82.50	$115.00	100.8	29.60
New Jersey	101	46.00	72.30	93.00	119.00	100	49.17	70.00	97.50	124.50	102	34.62
Pennsylvania	101	40.96	64.78	91.09	117.76	100.5	43.92	70.82	97.27	123.50	100	27.56
Delaware	100	39.00	55.00	82.50	109.50	102	40.00	65.00	86.50	120.00	100	27.50
Maryland	101	35.40	53.30	77.50	98.00	100	41.38	63.75	91.00	118.00	104	26.25
Virginia	101.5	30.00	46.71	67.15	87.78	101	34.85	55.98	83.08	104.06	100.5	20.62
North Carolina	101	31.50	47.00	69.72	90.00	101	34.00	53.23	81.00	101.00	101.5	16.50
South Carolina	101.5	32.50	54.44	76.00	99.50	102	36.11	58.89	87.22	107.00	102	21.00
Georgia	102	33.62	54.10	76.50	99.00	102	37.35	58.00	87.23	110.00	101	17.30
Florida	103	26.11	49.00	72.50	98.33	103	26.00	46.00	85.83	110.42	103	16.68
Alabama	102	31.00	45.50	66.70	87.50	102	33.80	47.60	76.64	97.17	102	17.00
Mississippi	103	22.63	37.71	61.50	78.00	108	33.00	48.96	73.23	95.00	104	16.25
Louisiana	102	16.19	25.00	39.50	68.75	102	26.66	39.40	68.50	96.00	104	16.74
Texas	108	13.56	19.57	27.63	45.25	108	24.27	34.45	49.10	68.23	107	13.67
Arkansas	104	22.00	34.29	48.77	72.26	105	30.50	45.70	65.77	88.32	106	14.20
Tennessee	102	35.40	54.30	72.78	90.79	107	43.50	62.11	81.00	90.00	108	19.14
West Virginia	101	30.29	46.75	67.20	88.81	105	33.32	49.00	73.50	97.13	103	23.40
Kentucky	102	35.50	52.75	71.00	90.00	98	41.00	58.00	84.50	103.00	100	24.00
Ohio	97	38.00	60.50	85.60	111.50	98	38.24	59.00	82.00	104.40	100	28.75
Michigan	101	38.20	81.20	82.30	113.00	101	38.33	61.00	85.50	110.00	101	28.75
Indiana	101	39.54	60.31	81.50	102.00	98	40.00	60.20	83.00	103.77	103	25.50
Illinois	102	37.77	56.22	80.00	100.00	97	39.50	58.30	81.00	102.50	104	25.20
Wisconsin	103	32.46	52.26	75.20	102.24	99	33.60	53.00	78.50	103.27	107	25.00
Minnesota	103	33.00	51.20	76.60	102.00	102	35.50	52.65	76.00	104.40	105	22.30
Iowa	105	33.48	50.20	72.40	95.00	103	36.40	54.60	80.00	102.00	103	22.32
Missouri	102	31.33	44.85	60.00	80.00	101	37.50	54.11	73.50	95.00	100	19.30
Kansas	104	26.50	41.20	59.50	80.00	100	31.00	46.75	71.00	95.60	102	20.36
Nebraska	105	23.61	45.50	70.63	95.00	108	37.42	60.00	85.67	103.00	.....	22.50
California	.....	25.30	38.48	58.00	92.00	105	32.80	52.64	78.50	105.00	108	31.38
Oregon	102	22.55	33.36	47.50	71.00	102	27.00	44.50	62.50	83.50	104	28.00
Nevada	.....	17.50	32.50	50.00	100.00	110	25.00	35.00	77.50	150.00	101	35.50
Colorado	102	25.00	37.23	55.75	74.62	97	39.00	52.50	70.00	101.00	103	34.40
Arizona	.....	10.00	20.00	30.00	42.50	.....	.....	.....	.....	.....	102	22.50
Dakota	107	32.30	51.00	73.60	101.24	.....	36.53	54.40	82.00	104.00	107	28.00
Idaho	.....	16.50	24.67	37.67	58.00	98	31.00	43.00	61.00	82.00	.....	34.33
Montana	107	21.25	29.38	43.00	58.00	96	23.67	35.00	50.00	82.25	101	35.25
New Mexico	105	11.50	15.67	27.67	45.50	100	14.60	30.00	40.00	66.00	102	21.67
Utah	.....	15.75	25.33	36.17	52.00	110	19.00	28.33	40.00	62.86	104	26.10
Washington	102	25.64	39.20	61.50	87.00	100	26.00	41.50	61.75	94.83	.....	34.50
Wyoming	110	22.50	30.00	37.40	57.50	.....	30.00	50.00	70.00	87.50	.....	36.70
Average	.....	30.98	48.14	66.85	91.27	.....	36.36	52.96	75.43	96.99	.....	23.94

Table showing the estimated number of animals on farms, etc.—Continued.

States and Territories.	Oxen and other cattle.					Sheep.			Hogs.		
	Total number compared with that of January, 1888.	Average price per head.				Total number compared with that of January, 1888.	Average price per head.		Total number compared with that of January, 1888.	Average price per head.	
		Under one year old.	Between one and two years old.	Between two and three years old.	Over three years old.		Under one year old.	Over one year old		Under one year old.	Over one year old.
	P. ct.					P. ct.			P. ct.		
Maine	100	$9.00	$14.00	$23.00	$37.92	100	$2.40	$3.20	100	$8.00	$16.78
New Hampshire	100	9.20	14.00	23.00	38.42	95	2.35	3.20	95	8.50	16.75
Vermont	103	8.00	13.00	23.00	37.50	93	2.50	3.25	101	7.25	15.00
Massachusetts	99	10.43	17.25	26.40	39.60	95	2.95	3.30	100	8.88	18.00
Rhode Island	103	9.75	16.50	25.75	38.75	98	3.01	3.75	103	8.13	15.50
Connecticut	101	9.75	17.25	26.42	39.42	96	3.21	4.08	100	8.25	15.13
New York	99	9.50	17.00	27.30	41.35	99	2.90	3.46	99	6.80	13.35
New Jersey	100	10.45	17.82	28.27	42.65	98	3.50	3.93	97	7.27	13.69
Pennsylvania	100.3	9.44	16.30	25.33	35.20	95	2.58	3.32	101	6.26	12.53
Delaware	100	9.50	14.50	21.00	32.50	100	2.50	3.25	100	6.00	10.05
Maryland	97	9.64	14.50	21.00	31.23	95	2.68	3.53	96	5.00	9.55
Virginia	99	7.00	11.27	18.00	24.60	98	2.13	2.63	102	3.10	6.60
North Carolina	100	4.50	7.41	11.54	16.00	98	1.08	1.50	101	2.68	5.60
South Carolina	100	5.66	8.50	13.00	18.55	98	1.30	1.90	106	2.75	6.60
Georgia	98	5.01	7.39	12.27	17.00	96	1.10	1.62	101	2.76	5.54
Florida	101	4.40	6.66	8.29	13.26	99	1.11	2.11	106	1.64	4.08
Alabama	102	4.25	6.50	9.62	13.80	97	1.05	1.58	102	2.69	5.26
Mississippi	102	4.52	6.60	9.42	13.77	102	1.11	1.60	107	2.26	4.90
Louisiana	104	4.28	7.17	10.53	14.67	102	1.08	1.72	110	2.20	5.27
Texas	......	4.45	6.53	9.50	13.24	103	1.00	1.65	97	2.70	5.77
Arkansas	107	4.00	5.48	9.00	13.26	102	1.10	1.68	102	1.52	4.25
Tennessee	103	5.64	9.80	14.70	20.50	102	1.36	1.90	110	3.00	6.47
West Virginia	101	8.00	14.27	23.00	32.40	102	1.75	2.55	105	3.39	7.27
Kentucky	100	8.20	14.20	21.30	33.00	101	2.10	2.75	......	3.50	7.80
Ohio	99	9.87	17.25	28.50	38.00	99	2.00	3.00	103	5.54	11.13
Michigan	102	8.70	16.00	26.60	37.00	101	2.15	3.12	100	5.43	11.24
Indiana	102	8.66	14.71	23.00	32.57	......	2.27	3.05	100	5.28	11.04
Illinois	103	9.15	15.00	23.40	31.50	95	2.00	3.00	......	5.88	11.50
Wisconsin	103	7.20	12.60	19.56	29.00	87	2.00	2.60	88	5.82	11.16
Minnesota	105	7.20	12.50	19.10	28.00	......	1.78	2.47	95	5.15	11.16
Iowa	100	8.45	14.62	22.40	30.75	......	1.80	2.75	......	6.20	11.00
Missouri	101	7.20	12.50	18.75	26.50	102	1.36	2.00	......	3.45	7.71
Kansas	105	7.70	13.60	19.50	27.64	88	1.32	2.00	115	4.30	8.20
Nebraska	......	8.23	14.30	21.00	27.41	......	1.34	2.11	97	5.40	11.00
California	105	8.70	14.83	21.72	27.17	......	1.30	2.10	......	4.16	8.13
Oregon	102	8.00	13.12	19.54	26.85	101	1.33	1.92	102	3.75	7.50
Nevada	......	10.00	13.75	22.50	31.25	105	1.90	3.17	96	3.25	8.50
Colorado	98	9.85	13.70	20.85	26.70	98	1.71	2.42	......	6.00	11.60
Arizona	105	7.25	10.00	14.00	19.00	101	1.50	2.00	98	3.50	9.50
Dakota	106	8.20	13.56	21.28	30.61	90	2.00	2.72	85	5.51	11.00
Idaho	98	9.50	13.17	23.00	32.50	......	.75	1.87	......	3.25	8.83
Montana	103	12.50	15.60	24.00	33.00	110	2.17	2.63	105	6.75	12.50
New Mexico	......	7.00	9.30	15.07	20.56	97	.75	1.33	110	4.30	7.25
Utah	97	7.37	12.53	17.70	22.80	......	1.48	2.12	......	6.86	12.58
Washington	105	11.50	16.60	27.00	37.00	102	1.35	2.10	105	4.45	9.00
Wyoming	90	11.17	14.67	20.55	31.35	108	1.71	2.26	105	7.00	15.00
Average	......	7.31	11.93	18.46	24.80	......	1.61	2.36	......	4.53	8.70

Table showing the estimated number of animals on farms and ranches, total value of each kind, and average price, January 1, 1889.

States and Territories.	Horses.			Mules.		
	Number.	Average price.	Value.	Number.	Average price.	Value.
Maine	96,754	$94.40	$9,133,393	....	....	....
New Hampshire	50,876	89.69	4,563,006	....	....	....
Vermont	86,962	83.75	7,283,194	....	....	....
Massachusetts	66,498	106.68	7,094,189	....	....	....
Rhode Island	10,156	110.43	1,121,554	....	....	....
Connecticut	50,369	103.56	5,216,394	....	....	....
New York	680,758	95.64	65,107,695	5,288	$103.27	$546,110
New Jersey	95,341	104.90	10,001,266	9,501	119.47	1,135,075
Pennsylvania	600,922	95.06	57,121,786	24,264	110.05	2,670,233
Delaware	23,000	94.03	2,162,690	4,184	114.40	478,670
Maryland	131,619	79.49	10,462,758	13,625	106.37	1,449,252
Virginia	246,969	70.85	17,496,863	36,083	88.49	3,193,125
North Carolina	151,205	76.58	11,579,404	90,844	84.90	7,712,432
South Carolina	66,955	90.66	6,070,267	76,960	97.71	7,520,098
Georgia	112,261	85.03	9,545,203	152,647	97.79	14,928,033
Florida	33,725	83.05	2,800,739	12,871	98.49	1,267,668
Alabama	133,470	74.32	9,919,207	140,449	84.97	11,933,953
Mississippi	138,087	67.41	9,308,519	172,312	85.26	14,691,343
Louisiana	122,206	54.38	6,645,833	86,168	85.82	7,395,033
Texas	1,323,867	33.22	43,973,694	208,967	53.76	11,233,342
Arkansas	187,153	57.66	10,790,713	128,580	72.81	9,362,065
Tennessee	306,269	71.94	22,032,245	208,405	71.65	14,933,102
West Virginia	139,664	66.17	9,241,237	6,799	74.49	506,459
Kentucky	398,548	70.77	28,207,215	159,039	73.26	11,651,979
Ohio	701,461	86.92	60,969,557	24,230	87.65	2,123,794
Michigan	463,502	92.85	43,034,316	6,095	102.25	623,209
Indiana	648,133	81.65	52,917,495	53,294	82.86	4,415,783
Illinois	1,091,236	78.38	85,529,225	112,191	81.89	9,187,623
Wisconsin	425,068	80.92	34,395,550	7,851	90.65	711,693
Minnesota	390,874	83.12	32,491,024	11,188	93.12	1,041,779
Iowa	1,053,173	74.99	78,975,356	47,018	85.14	4,003,124
Missouri	797,746	61.60	49,140,432	227,819	69.46	15,825,020
Kansas	660,289	65.46	43,223,153	86,104	80.32	6,916,125
Nebraska	433,629	76.69	33,255,585	44,458	90.41	4,019,378
California	368,400	70.19	25,857,259	40,765	83.78	3,415,201
Oregon	181,399	50.51	9,161,808	3,218	63.02	202,813
Nevada	51,013	67.50	3,443,350	2,369	98.11	232,413
Colorado	130,033	61.11	7,946,430	8,000	95.34	762,720
Arizona	29,700	48.50	1,440,450	2,850	70.25	200,213
Dakota	254,781	78.03	20,659,590	16,850	94.74	1,596,324
Idaho	136,500	47.50	6,483,750	1,671	61.15	102,182
Montana	200,458	47.03	9,427,934	5,316	58.88	312,980
New Mexico	42,560	33.52	1,426,788	10,803	54.63	590,176
Utah	132,761	34.15	4,534,358	4,055	47.42	192,303
Washington	98,044	64.84	6,357,223	1,243	83.06	104,367
Wyoming	108,900	42.66	4,645,130	3,200	80.40	257,280
Total	13,663,294	71.89	982,194,827	2,257,574	79.49	179,444,481

States and Territories.	Milch cows.			Oxen and other cattle.		
	Number.	Average price.	Value.	Number.	Average price.	Value.
Maine	174,207	$28.00	$4,877,796	185,160	$25.91	$4,798,092
New Hampshire	100,011	29.63	2,963,326	141,670	26.96	3,818,816
Vermont	232,319	26.20	6,086,758	185,773	25.69	4,771,598
Massachusetts	183,925	33.50	6,161,488	103,973	27.98	2,908,977
Rhode Island	23,341	33.00	770,253	13,549	30.91	418,799
Connecticut	130,968	34.50	4,518,396	111,025	30.25	3,358,237
New York	1,552,373	29.60	45,950,241	842,617	31.23	26,318,317
New Jersey	181,676	34.62	6,289,623	68,541	31.27	2,143,334
Pennsylvania	929,871	27.56	25,613,465	869,660	24.54	21,344,240
Delaware	28,683	27.50	788,783	27,137	25.92	703,391
Maryland	140,422	26.25	3,686,078	134,037	21.99	2,947,584
Virginia	259,082	20.62	5,342,271	419,523	17.27	7,245,160
North Carolina	247,414	16.50	4,082,331	419,383	11.41	4,783,441
South Carolina	149,119	21.00	3,131,499	212,521	13.21	2,806,869
Georgia	340,979	17.30	5,898,937	586,683	11.78	6,911,890
Florida	54,407	16.68	907,509	582,681	8.99	5,239,642
Alabama	302,723	17.00	5,146,291	454,042	9.63	4,370,248
Mississippi	297,340	16.25	4,831,775	437,487	9.85	4,307,671
Louisiana	169,155	16.74	2,831,655	281,649	10.43	2,936,613

Table showing the estimated number of animals on farms, etc.—Continued.

States and Territories.	Milch cows.			Oxen and other cattle.		
	Number.	Average price.	Value.	Number.	Average price.	Value.
Texas	826,806	$13.67	$11,302,438	7,096,884	$9.29	$65,907,346
Arkansas	322,668	14.20	4,581,886	501,891	9.10	4,566,305
Tennessee	366,738	19.14	7,019,365	475,076	12.86	6,109,192
West Virginia	176,411	23.40	4,128,017	283,701	18.07	5,127,091
Kentucky	313,953	24.00	7,534,872	529,018	20.15	10,659,723
Ohio	783,481	28.75	22,525,079	957,865	25.16	24,096,444
Michigan	441,676	28.75	12,698,185	521,634	24.07	12,557,817
Indiana	573,670	25.50	14,628,585	912,231	21.47	19,582,493
Illinois	974,975	25.20	24,569,370	1,530,327	21.17	32,398,551
Wisconsin	586,598	25.00	14,664,950	659,975	19.42	12,818,562
Minnesota	455,664	22.30	10,161,307	514,380	18.10	9,309,253
Iowa	1,293,095	22.32	28,861,880	2,095,253	20.46	42,865,531
Missouri	737,259	19.30	14,229,099	1,443,748	16.87	24,349,524
Kansas	652,883	20.36	13,292,698	1,663,111	18.26	30,361,088
Nebraska	400,066	22.50	9,001,485	1,187,611	18.96	22,517,226
California	258,296	31.38	8,105,328	726,880	19.37	14,080,181
Oregon	82,157	28.00	2,300,396	610,182	18.98	11,580,343
Nevada	18,217	35.50	646,704	355,740	20.37	7,248,198
Colorado	64,914	34.40	2,233,042	1,028,366	20.00	20,562,696
Arizona	16,624	22.50	374,040	441,000	17.50	7,717,500
Dakota	239,057	28.00	6,693,596	813,878	20.42	16,619,318
Idaho	31,750	34.33	1,089,978	415,830	20.00	8,316,600
Montana	31,443	35.25	1,108,366	962,535	21.82	21,002,514
New Mexico	19,782	21.67	428,676	1,383,357	13.48	18,650,697
Utah	51,873	26.10	1,353,885	421,950	15.41	6,501,162
Washington	72,731	34.50	2,509,220	315,710	25.07	7,913,901
Wyoming	8,323	36.70	305,454	1,107,173	19.59	21,684,642
Total	15,298,625	23.94	366,226,376	35,032,417	17.05	597,236,812

States and Territories.	Sheep.			Hogs.		
	Number.	Average price.	Value.	Number.	Average price.	Value.
Maine	547,725	3.00	1,643,175	73,188	9.76	714,026
New Hampshire	194,772	2.94	573,603	51,679	10.56	545,862
Vermont	365,770	3.04	1,111,941	77,117	9.26	714,486
Massachusetts	59,505	3.21	191,160	65,814	11.07	722,944
Rhode Island	20,435	3.57	72,851	13,659	9.60	131,183
Connecticut	47,231	3.88	183,251	61,776	9.63	594,654
New York	1,548,426	3.32	5,140,774	679,526	8.70	5,911,539
New Jersey	103,170	3.82	393,924	186,063	9.52	1,770,761
Pennsylvania	935,646	3.08	2,884,783	1,037,752	8.08	8,383,271
Delaware	22,294	3.05	67,942	42,654	6.81	290,475
Maryland	152,241	3.27	497,295	270,141	6.59	1,780,903
Virginia	435,846	2.49	1,085,257	827,589	4.15	3,434,495
North Carolina	419,009	1.37	575,718	1,279,102	3.76	4,809,936
South Carolina	105,187	1.72	180,922	583,176	4.14	2,412,015
Georgia	424,583	1.47	626,005	1,549,531	3.76	5,827,476
Florida	91,959	1.87	171,964	325,474	2.52	819,675
Alabama	301,303	1.42	426,554	1,403,671	3.59	5,038,477
Mississippi	252,787	1.45	367,300	1,312,557	3.16	4,144,529
Louisiana	116,244	1.52	176,877	631,203	3.43	2,163,763
Texas	4,659,451	1.45	6,749,215	2,210,710	3.93	8,683,669
Arkansas	224,570	1.49	334,295	1,569,127	2.61	4,098,561
Tennessee	526,926	1.72	907,261	2,038,377	3.97	8,095,620
West Virginia	484,432	2.28	1,103,536	454,417	4.40	1,998,888
Kentucky	805,978	2.53	2,038,318	2,147,716	4.62	9,918,152
Ohio	4,065,556	2.71	11,017,657	2,748,436	6.88	18,913,639
Michigan	2,134,134	2.81	5,996,062	906,255	6.94	6,289,951
Indiana	1,420,000	2.79	3,965,492	2,371,085	6.89	16,343,416
Illinois	773,468	2.67	2,065,160	5,275,000	7.45	39,317,740
Wisconsin	793,146	2.41	1,909,895	989,002	7.42	7,340,375
Minnesota	337,500	2.25	759,105	522,303	6.95	3,631,574
Iowa	540,700	2.45	1,322,552	6,750,000	7.54	50,922,000
Missouri	1,109,444	1.79	1,984,573	5,200,000	4.73	24,585,600
Kansas	730,522	1.78	1,297,115	2,734,195	5.35	14,636,148
Nebraska	342,000	1.86	634,717	2,264,489	7.08	16,032,584
California	3,956,000	1.88	7,453,104	647,000	5.59	3,616,213
Oregon	2,959,424	1.73	5,105,894	225,137	5.18	1,165,084
Nevada	694,046	2.80	1,944,509	20,244	5.35	108,308
Colorado	1,114,932	2.25	2,508,151	28,103	7.40	207,964
Arizona	665,147	1.80	1,197,265	16,112	6.00	96,672
Dakota	242,117	2.52	609,747	453,875	7.16	3,248,386

Table showing the estimated number of animals on farms, etc.—Continued.

States and Territories.	Sheep.			Hogs.		
	Number.	Average price.	Value.	Number.	Average price.	Value.
Idaho	374,890	$2.40	$899,736	65,000	$7.50	$487,500
Montana	1,391,500	2.48	3,448,415	23,403	8.48	198,342
New Mexico	3,514,473	1.14	4,001,579	21,935	5.48	120,204
Utah	1,468,500	1.90	2,793,674	50,148	8.63	432,939
Washington	560,883	1.84	1,034,829	95,607	6.09	582,058
Wyoming	565,207	2.10	1,187,217	2,744	9.16	25,136
Total	42,599,079	2.13	90,640,369	50,301,592	5.79	291,307,193

CONDITION OF FARM ANIMALS.

HORSES.

The condition of horses at the close of the winter of 1888-'89 is better than usual, owing to the mildness of the season. It is represented by the average percentage 98.4, an unusually high figure. The lowest average is in New Mexico, which returns 5 per cent. below normal. The Southwestern States report their horses three points below full condition, as well as Georgia and Alabama; and New Hampshire and Vermont make the same averages. The bad weather of September in New England, the frosted herbage and injured corn, were not a good preparation for wintering horses. Dakota also suffered from early frost, and reports a general average of 96. Ohio and Illinois, at 98, show good condition, but slightly lower than many other States. As a whole, the condition of horses shows how favorable the season has been, and with what care and liberality of feeding our farmers treat this favorite and valuable animal.

The cases in which any serious disease has been prevalent over any considerable district are remarkably few in number. The usual list of diseases is reported. Diseases of a contagious nature are reported in a few localities. Pink-eye is mentioned occasionally, the cases generally appearing in a mild form and in the middle latitudes. An occasional mention of glanders is made. Attacks of charbon and deaths from buffalo gnats are less frequent than usual in the Southwest. Pneumonia, lung fever and other lung diseases, strangles, diphtheria, laryngitis and other diseases of the throat, catarrhal fever, catarrh, nasal gleet, kidney troubles, congestion of the bowels, influenza, coughs, colds, rheumatism, brain fever, cerebro-spinal meningitis, farcy, sweeny, "big head," "big shoulder," a few cases of skin disease, and a few of hydrophobia are diseases mentioned, some of them as prevalent in one county or more, but none of them as prevailing over large districts or in any considerable number of localities.

The losses from all causes for the entire country average 1.5 per cent. as compared with 1.8 a year ago. The table on losses given below, when compared with the corresponding table for last year, shows a noticeable reduction in the percentage in many of the States and Territories in which animals are provided with comparatively little shelter through the winter season. There are States and Ter-

ritories in which there is little or no reduction, or even an increase, in the percentage; while the reduction is quite marked in some of the States in which the provisions for shelter are generally good.

States and Territories.	Horses.	Losses.		States and Territories.	Horses.	Losses.	
		Per cent.	Number.			Per cent.	Number.
Maine	96,754	1.0	968	Ohio	701,461	1.1	7,716
New Hampshire	50,876	1.7	865	Michigan	463,502	1.3	6,026
Vermont	86,962	1.0	870	Indiana	648,133	1.5	9,722
Massachusetts	66,498	1.2	798	Illinois	1,091,236	1.0	10,912
Rhode Island	10,156	1.1	112	Wisconsin	425,068	1.5	6,376
Connecticut	50,369	1.6	806	Minnesota	390,874	1.4	5,472
New York	680,758	1.7	11,573	Iowa	1,053,173	1.6	16,851
New Jersey	95,341	1.3	1,239	Missouri	797,746	1.5	11,966
Pennsylvania	600,922	1.4	8,413	Kansas	660,289	1.2	7,923
Delaware	23,000	1.5	345	Nebraska	433,629	1.3	5,637
Maryland	131,619	1.3	1,711	California	368,400	1.2	4,421
Virginia	246,969	1.5	3,705	Oregon	181,399	1.1	1,995
North Carolina	151,205	1.5	2,268	Nevada	51,013	2.8	1,428
South Carolina	66,955	1.4	937	Colorado	130,033	1.4	1,820
Georgia	112,261	1.5	1,684	Arizona	29,700	1.2	356
Florida	33,725	2.5	843	Dakota	264,781	1.3	3,442
Alabama	133,470	2.0	2,669	Idaho	136,500	1.2	1,638
Mississippi	138,087	1.6	2,209	Montana	200,458	1.5	3,007
Louisiana	122,206	1.7	2,078	New Mexico	42,560	3.7	1,575
Texas	1,323,867	2.0	26,477	Utah	132,761	1.2	1,593
Arkansas	187,153	2.2	4,117	Washington	98,044	1.2	1,177
Tennessee	306,269	1.4	4,288	Wyoming	108,900	1.2	1,307
West Virginia	139,664	1.5	2,095				
Kentucky	398,548	1.6	6,377	Total	13,663,294	1.5	199,807

CATTLE.

Cattle come out of winter quarters in unusually high condition both as regards flesh and general health. Hay and forage were generally abundant, the winter comparatively mild, especially in sections where the loss from stress of weather is usually greatest, and as a consequence vigor was well maintained during the winter months. Spring pasturage was available earlier than usual in nearly all sections of the country, and with the present good status of stock the coming season should be a prosperous one to stock growers, at least so far as the health and exemption from losses of the herds is concerned. There are occasional reports of poor condition, but usually from very limited areas and from purely local causes. Scarcity of food and consequent thinness in flesh is the usual complaint, with some references to poor condition resulting from exposure in spite of the comparatively mild winter. These unfavorable returns are, however, very scattering, and serve mainly to show by contrast the general high averages.

As usual, condition is highest in New England and the Northern Middle States, attributable almost entirely to the care in housing and feeding stock which is shown in this section. In spite of a more rigorous climate and longer winter-feeding season, our returns, year after year, show better status here than in those sections which by nature are more favored. Proper feed and shelter are provided, and the increased care and attention necessary are fully repaid by the better health and fattening possibilities of the stock. Animals underfed and exposed to winter blasts are so reduced in vitality that the greater part of the summer is passed in recovering from the effects of the abuse, and their existence becomes a constant struggle. While pasturage exists they are storing up vitality to be needlessly

wasted during the inclement season, growth is checked, and full development made impossible.

The present returns show that along the Atlantic coast as far south as Virginia, condition, as regards healthfulness and flesh, is almost perfect. With 100 representing perfect condition, only two States fall below 99, a condition seldom reported over so large an area. In the Gulf States, where less feed and shelter are required, and less than necessary are always given, the returns are lower, the whole district not varying far from 95. North of the Ohio River the effect of better care is visible, the averages ranging from 97 to 99. In the ranch regions, where usually condition is low as cattle enter upon spring pasture, the present returns show how favorable the past winter has been. In this section the attention paid to the securing of winter feed and shelter is steadily increasing, and the annual losses as steadily decreasing.

Less than the usual run of bovine diseases are mentioned by correspondents, and there have been no epidemics or serious loss from any wide-spread disease. Disorders have been local and isolated in character, and have appeared among individual herds rather than in counties or even smaller definite districts.

Blackleg is occasionally met with among young and thrifty cattle, especially where pastured on low, rich ground. Murrain, a name including many different and obscure disorders, is mentioned in a number of counties in the States from Alabama to Arkansas, but the loss has been slight, generally much less than usual. Diseases following from exposure, wet weather, and occasionally insufficient food, are mentioned locally in Florida, Alabama, and Mississippi. Charbon and the bite of the buffalo gnat cause annually some loss in Louisiana, but the present reports make very little complaint from these causes.

Pleuro-pneumonia is mentioned less frequently than for many years. Neither the disease nor anything mistaken for it is mentioned in any State except New York, New Jersey, and Maryland, and in these States almost invariably in counties adjacent to the large cities which have heretofore been centers of infection. This disease has been persistently and successfully fought, and to all appearances is in a fair way to be stamped out entirely. When mentioned by our correspondents, it is usually with a statement that it is under control and that no alarm is felt. The report from Burlington County, N. J., fairly represents the tenor of the reports from all other counties where the disease is noted. It says: "While no disease can be said to be unusually prevalent, pleuro-pneumonia was introduced on some farms by purchased stock, but it has been promptly met by isolation and the slaughter of those affected. We are favored with medical officials, alert and skillful, to whom we are indebted for the restraint and eradication of the disease."

The correspondent for San Benito County, Cal., thus reports the ravages of an obscure disease: "On the Topo grant, lying in both San Benito and Monterey Counties, nearly all died. Experts differ about what the disease was, some calling it Texas fever, others anthrax or murrain."

Losses of cattle from disease, exposure, and all causes during the past year have been very light. A mild winter and generally sufficient forage have jointly materially lowered the usual death-rate. Last year the losses were spoken of as considerably under the average for a series of years; the present returns make the aggregate loss, in spite of the increased numbers of cattle, still smaller, or less than

one and a quarter million head, against nearly one and a half million. The loss, both by percentages and by actual numbers, is largest in the South and in the Territories, but in almost every State it is reported less than that of the previous year. By far the larger part of it is due to exposure and partial starvation. The loss in New England and the North Atlantic States ranges from 1 to 2 per cent., in the South Atlantic and Gulf States from 2.1 to 3.5, except in Florida, where, on account of the excessive rain-fall of the winter, mortality reached the unusual figure of 5.5 per cent. The States of the Ohio Valley and the Northwest return small loss; less than 2 per cent. West of the Mississippi, as usual, it was greater, ranging from 1.8 in Kansas to 4.2 in New Mexico. The average loss for the country was 2.4 per cent. of all cattle, a figure much lower than the average for a series of years. The loss during 1887-'88 was 2.9; that reported for 1886-'87, 4.4, against 4 for 1885-'86, and 4.2 for 1884-'85.

The following statement shows the aggregate number of cattle in each State and Territory, with the percentage and the aggregate of loss in each:

States and Territories.	Milch cows, oxen, and other cattle.	Losses.	
		Per cent.	Number.
Maine	359,367	1.3	4,672
New Hampshire	241,681	1.1	2,658
Vermont	418,092	1.2	5,017
Massachusetts	287,898	1.0	2,879
Rhode Island	36,890	1.0	369
Connecticut	241,993	1.8	4,356
New York	2,394,990	2.0	47,900
New Jersey	250,217	1.9	4,754
Pennsylvania	1,799,031	1.3	23,387
Delaware	55,820	1.2	670
Maryland	274,459	1.8	4,940
Virginia	678,605	1.9	12,893
North Carolina	666,797	2.2	14,670
South Carolina	361,640	2.1	7,594
Georgia	927,662	3.4	31,541
Florida	637,088	5.5	35,040
Alabama	756,765	3.0	22,703
Mississippi	734,827	3.2	23,514
Louisiana	450,804	3.4	15,327
Texas	7,923,690	3.5	277,329
Arkansas	824,559	2.6	21,439
Tennessee	841,814	1.7	14,311
West Virginia	460,112	2.0	9,202
Kentucky	842,971	1.8	15,173
Ohio	1,741,346	1.5	26,120
Michigan	963,310	1.8	17,340
Indiana	1,485,901	2.0	29,718
Illinois	2,505,302	1.9	47,601
Wisconsin	1,246,573	1.9	23,685
Minnesota	970,044	2.0	19,401
Iowa	3,388,348	1.6	54,214
Missouri	2,181,007	2.0	43,620
Kansas	2,315,994	1.8	41,688
Nebraska	1,587,677	2.2	34,929
California	985,176	2.3	22,659
Oregon	692,339	2.0	13,847
Nevada	373,957	3.5	13,088
Colorado	1,093,230	3.0	32,798
Arizona	457,624	3.5	16,017
Dakota	1,052,935	2.0	21,059
Idaho	447,580	2.0	8,952
Montana	993,978	2.5	24,849
New Mexico	1,403,139	4.2	58,932
Utah	473,823	3.7	17,531
Washington	388,441	2.5	9,711
Wyoming	1,115,496	2.7	30,118
Total	50,331,042	2.4	1,210,215

SHEEP.

The past season has been very favorable to the condition of sheep, which averages for the entire country 97.4 on the basis of 100 as the standard of normal healthfulness and average condition as to flesh.

But little serious disease is reported from any part of the country, but the plague of sheep-killing dogs is unabated, and the pre-eminence of these animals as a cause of loss to sheep-owners is even less disputable than usual. Their ravages are most general in the South, but a number of counties in Northern States report exceedingly heavy losses from their depredations.

The percentage of losses during the twelve months from April 1, 1888, to April 1, 1889, has been light, being only 3.8 as compared with 4.6 for the twelve months ended a year ago. In all the States and Territories except eight the percentage of losses is reduced, and in a number of cases the reduction is large.

States and Territories.	Number.	Losses.		States and Territories.	Number.	Losses.	
		Per cent.	Number.			Per cent.	Number.
Maine	547,725	2.6	14,241	Ohio	4,065,556	3.3	134,163
New Hampshire	194,772	2.0	3,895	Michigan	2,134,134	2.6	55,487
Vermont	365,770	2.3	8,413	Indiana	1,420,000	3.2	45,440
Massachusetts	59,505	1.8	1,071	Illinois	773,468	3.0	23,204
Rhode Island	20,435	1.5	307	Wisconsin	793,146	3.5	27,760
Connecticut	47,231	2.5	1,181	Minnesota	337,500	3.0	10,125
New York	1,548,426	2.7	41,808	Iowa	540,700	3.5	18,925
New Jersey	103,170	1.5	1,548	Missouri	1,109,444	3.9	43,268
Pennsylvania	935,646	3.0	28,069	Kansas	730,522	2.6	18,994
Delaware	22,294	2.0	446	Nebraska	342,000	2.8	9,576
Maryland	152,241	2.2	3,349	California	3,956,000	4.2	166,152
Virginia	435,846	3.5	15,255	Oregon	2,959,424	4.2	1 4,296
North Carolina	419,009	3.7	15,503	Nevada	694,046	5.0	34,702
South Carolina	105,187	3.6	3,787	Colorado	1,114,932	5.0	55,747
Georgia	424,583	6.0	25,475	Arizona	665,147	4.4	29,266
Florida	91,959	5.9	5,426	Dakota	242,117	3.2	7,748
Alabama	301,303	4.5	13,559	Idaho	374,890	3.0	11,247
Mississippi	252,787	4.6	11,628	Montana	1,391,500	3.2	44,528
Louisiana	116,244	4.7	5,463	New Mexico	3,514,473	5.0	175,724
Texas	4,659,451	4.2	195,697	Utah	1,468,500	5.5	80,768
Arkansas	224,570	4.0	8,983	Washington	560,883	2.9	16,266
Tennessee	526,926	3.8	20,023	Wyoming	565,207	3.0	16,956
West Virginia	484,432	3.6	17,440				
Kentucky	805,978	3.8	30,627	Total	42,599,079	3.8	1,623,536

HOGS.

Hogs have shared with other classes of farm animals in the advantages of a mild winter with abundant food. They are now in generally better condition as to health and flesh than usual at this time.

The ravages of diseases have been much smaller than usual during the year, while losses from exposure and other causes have been practically nothing. Cholera, a designation which is made to include almost any fatal disorder, is as usual reported from almost every section of the country, but only in scattered localities was the loss heavier than usual.

The aggregate of loss amounts to 3,105,513 head, or 6.2 per cent. of the whole number. This percentage is smaller than for recent years, the returns for 1888 making it 7.8; for 1887, 13.4; for 1886, 13, and for 1885, 9.1. The following statement shows both the aggregate number and the losses of the year:

States and Territories.	Number.	Losses.		States and Territories.	Number.	Losses.	
		Per cent.	Number.			Per cent.	Number.
Maine	73,188	1.3	951	Ohio	2,748,436	3.8	104,441
New Hampshire	51,679	1.8	930	Michigan	906,255	2.3	20,844
Vermont	77,117	1.5	1,157	Indiana	2,371,085	6.5	154,121
Massachusetts	65,314	1.3	849	Illinois	5,275,000	6.0	316,500
Rhode Island	13,659	1.5	205	Wisconsin	989,002	4.6	45,494
Connecticut	61,776	1.4	865	Minnesota	522,303	3.4	17,758
New York	679,526	2.5	16,988	Iowa	6,750,000	5.0	337,500
New Jersey	186,063	2.0	3,721	Missouri	5,200,000	6.7	348,400
Pennsylvania	1,037,752	2.3	23,868	Kansas	2,734,195	5.8	158,58[illegible]
Delaware	42,654	10.0	4,265	Nebraska	2,264,489	5.5	124,547
Maryland	270,141	4.1	11,076	California	647,000	2.5	16,175
Virginia	827,589	5.0	41,379	Oregon	225,137	2.3	5,178
North Carolina	1,279,102	6.3	80,583	Nevada	20,244	2.0	405
South Carolina	583,176	7.5	43,738	Colorado	28,103	2.0	562
Georgia	1,549,531	13.0	201,439	Arizona	16,112	2.5	403
Florida	325,474	12.5	40,684	Dakota	453,875	3.4	15,432
Alabama	1,403,[illegible]71	11.0	154,404	Idaho	65,000	3.0	1 950
Mississippi	1,312,557	8.0	105,005	Montana	23,403	2.5	585
Louisiana	631,203	9.0	56,808	New Mexico	21,935	6.7	1,470
Texas	2,210,710	5.5	121,589	Utah	50,148	5.0	2,507
Arkansas	1,569,127	10.5	164,758	Washington	95,607	2.6	2,486
Tennessee	2,038,377	9.7	197,723	Wyoming	2,744	2.5	69
West Virginia	454,417	4.8	21,812				
Kentucky	2,147,716	6.3	135,306	Total	50,301,592	6.2	3,105,513

COMMERCIAL MOVEMENT OF FARM ANIMALS.

The receipts and shipments of cattle reported at Chicago, Saint Louis, Kansas City, and Peoria for the years 1878 and 1888, respectively, are as follows:

Cities.	1878.		Cities.	1888.	
	Receipts.	Shipments.		Receipts.	Shipments.
Chicago	1,083,068	699,108	Chicago	2,611,543	968,385
Saint Louis	406,235	261,723	Saint Louis	546,875	336,206
Kansas City	175,344	131,761	Kansas City	1,056,086	682,622
Peoria	36,088	42,326	Peoria	70,448	68,960

The receipts at these markets have much more than doubled in ten years, increasing from 1,700,735 to 4,284,952, a gain of 2,584,217. The shipments have advanced more slowly, from 1,134,918 to 2,056,173, a gain of 921,255. Chicago has maintained ascendency, keeping nearly the old proportion of shipments. Kansas City advanced from 175,344 to 1,056,086, a rate of increase much greater than that of Chicago. The differences between receipts and shipments if they represented the entire trade of each market, as they do not exactly, would show the number slaughtered in each place, both for local consumption and for shipment as dressed beef and beef products.

The receipts of cattle at sea-board cities are less than they were ten years ago, a fact not due to a decrease in consumption of Western beef, but to a radical change in its transportation to market. The suffering and deterioration incident to live-stock transit by railway, and the greater expense of transportation, have given an impetus to dressed-meat shipments in refrigerator cars, the results of which are exhibited in the figures showing decline in Western shipments and in sea-board receipts.

The aggregate receipts at the principal Eastern cities continued to increase till 1880, and have declined quite steadily since, to the extent of fully one-third of the total for that date. The following table gives the record since 1885, except that those of last year are not available:

Receipts and shipments of Western markets.

Years.	Chicago.		Saint Louis.		Kansas City.		Peoria.	
	Receipts.	Shipments.	Receipts.	Shipments.	Receipts.	Shipments.	Receipts.	Shipments.
1875	920,843	696,534	335,742	216,701	174,754	126,262	37,611	38,621
1876	1,096,745	797,724	349,043	220,430	183,378	120,840	40,538	42,719
1877	1,033,151	703,402	411,969	251,566	215,768	126,570	29,774	31,282
1878	1,083,068	699,108	406,235	261,723	175,344	131,761	36,088	42,326
1879	1,215,732	726,903	420,654	226,255	211,415	155,831	43,060	41,480
1880	1,382,477	886,614	424,720	228,879	244,709	194,421	42,935	41,341
1881	1,498,550	938,712	503,862	293,092	285,863	223,989	40,814	35,866
1882	1,582,530	921,009	443,169	188,486	439,671	359,012	34,897	32,955
1883	1,878,944	966,758	405,090	249,523	460,780	387,598	37,517	34,180
1884	1,817,697	791,884	450,717	315,433	533,526	443,001	37,891	34,351
1885	1,905,518	744,093	386,320	233,249	506,627	402,381	31,716	30,634
1886	1,963,900	704,675	377,550	212,958	490,971	370,350	40,121	39,657
1887	2,382,008	791,483	464,828	277,419	669,224	483,372	59,770	53,930
1888	2,611,543	968,385	546,875	336,206	1,056,086	682,622	70,448	68,960

Receipts at Eastern cities.

Years.	New York.	Boston.	Philadelphia.	Baltimore.	Total.
1875	457,057	145,285	152,830	112,679	867,851
1876	467,722	189,989	190,550	110,366	958,627
1877	507,832	155,907	203,470	112,862	980,071
1878	543,587	188,385	188,600	117,675	1,038,247
1879	575,159	183,556	216,780	150,829	1,126,324
1880	679,987	230,079	218,606	138,969	1,267,641
1881	692,570	204,928	225,521	122,174	1,245,193
1882	628,843	130,900	163,300	92,614	1,015,657
1883	674,632	161,162	236,050	94,349	1,166,193
1884	612,976	139,292	154,259	105,002	1,011,529
1885	562,447	112,995	194,644	90,870	960,956
1886	513,470	113,316	176,025	96,357	899,168
1887	498,048	99,584	122,297	85,166	805,095

SHEEP.

The increase in receipts of sheep from 521,592 in 1878 to 2,336,377 in 1888, indicates a rapidly enlarging consumption of mutton. While the difference between receipts and shipments is very marked, showing a large consumption in Western markets, the receipts of sheep at the sea-board, instead of falling off like those of cattle, show a material advance in the last ten years. The records of receipts, Western and Eastern, are as follows:

Receipts and shipments of Western markets.

Years.	Chicago.		Saint Louis.		Kansas City.		Peoria.	
	Receipts.	Shipments.	Receipts.	Shipments.	Receipts.	Shipments.	Receipts.	Shipments.
1875	418,948	243,604	125,679	37,784	25,327	17,742	3,216	3,160
1876	364,095	195,925	157,831	67,886	55,045	22,460	4,983	5,379
1877	310,840	155,354	200,502	87,569	42,190	28,320	3,628	3,379
1878	310,420	156,727	168,095	74,433	36,700	30,483	6,377	6,876
1879	325,119	159,266	182,648	88,083	61,684	47,782	5,312	5,750
1880	335,810	156,510	205,969	93,522	50,611	36,285	7,040	6,610
1881	493,624	253,938	334,426	170,395	79,924	61,078	11,270	6,750
1882	628,887	314,200	443,120	245,071	80,724	52,652	8,571	10,092
1883	749,917	801,630	398,612	217,370	119,665	61,979	9,533	10,086
1884	374,463	290,352	380,822	248,545	237,964	105,973	9,965	8,159
1885	1,003,598	260,277	362,858	233,391	221,801	115,755	9,496	9,174
1886	1,008,790	266,912	328,985	202,728	172,659	83,234	16,723	12,975
1887	1,360,862	445,094	417,425	287,018	209,956	103,126	22,222	22,995
1888	1,515,014	601,241	456,669	316,676	351,050	169,932	13,644	13,860

Receipts at Eastern cities.

Years.	New York.	Boston.	Philadelphia.	Baltimore.	Total.
1875	1,233,968	372,370	491,500	191,485	2,280,323
1876	1,211,086	348,510	548,850	223,267	2,331,713
1877	1,184,687	346,647	545,870	96,786	2,173,990
1878	1,349,622	372,787	650,400	220,135	2,592,944
1879	1,507,739	479,227	619,450	243,520	2,849,936
1880	1,656,955	476,785	623,494	248,047	3,005,281
1881	1,738,626	505,828	645,792	305,496	3,195,742
1882	2,066,502	626,608	614,000	202,241	3,509,351
1883	2,036,018	648,790	680,417	198,060	3,563,285
1884	2,041,774	628,991	683,546	216,286	3,570,597
1885	1,849,277	639,847	616,573	178,712	3,284,409
1886	1,997,751	524,089	583,579	219,645	3,125,064
1887	2,025,116	591,476	588,279	227,456	3,432,327
1888	....	....	....	....	....

SWINE.

The movement of swine has not materially increased at Western markets in the last ten years. The exports have fallen off, offsetting the increase of consumption as population advances; yet the Eastern receipts, which represent the consumption of a population continually increasing, are somewhat larger than in 1878. The figures are as follows:

Receipts and shipments of Western markets.

Years.	Chicago.		Saint Louis.		Kansas City.		Peoria.	
	Receipts.	Shipments.	Receipts.	Shipments.	Receipts.	Shipments.	Receipts.	Shipments.
1875	3,912,110	1,582,643	628,569	126,729	63,350	15,790	139,647	93,259
1876	4,190,006	1,131,635	877,160	232,876	153,777	26,264	163,646	96,044
1877	4,025,970	951,221	896,319	314,287	192,645	15,973	104,830	87,470
1878	6,339,654	1,266,906	1,451,634	528,627	427,777	91,671	235,500	207,938
1879	6,448,300	1,692,361	1,762.724	686,099	588,908	208,851	267,669	236,693
1880	7,059,355	1,394,990	1,840,684	770,769	676,477	152,920	304,167	265,419
1881	6,474,844	1,289,679	1,672,153	889,909	1,014,304	195,524	205,130	186,072
1882	5,817,504	1,747,722	846,228	264,584	963,036	191,325	161,939	163,797
1883	5,640,625	1,319,392	1,151,785	609,388	1,379,401	313,879	171,437	146,129
1884	5,351,967	1,392,615	1,474,475	678.874	1,723,586	590,133	173,902	169,440
1885	6.937,535	1,797,446	1,455,535	789,487	2,358,718	801,162	200,373	185,730
1886	6,718,761	2,090,784	1,264,471	530,362	2,264,484	538,005	275,000	214,950
1887	5,470,952	1,812,001	1,052,240	324,745	2,423,262	524,492	254,179	195,431
1888	4,921,712	1,751,829	929,230	294,869	2,008,984	413,937	244,195	221,361

Receipts at Eastern cities.

Years.	New York.	Boston.	Philadelphia.	Baltimore.	Total.
1875	1,388,517	331,989	243,300	279,631	2,243,437
1876	1,222,657	361,317	289,900	259,064	2,132,938
1877	1,268,596	330,604	242,400	322,945	2,164,545
1878	1,794,539	510,432	282,060	260,514	2,847,545
1879	1,725,537	582,615	341,450	356,524	3,006,126
1880	1,719,137	691,839	346,960	336,867	3,094,803
1881	1,533,526	708,900	367,876	338,551	2,948,853
1882	1,366,848	816,535	186,800	268,811	2,638,994
1883	1,586,243	771,757	383,312	271,148	3,012,460
1884	1,697,430	785,261	311,404	282,664	3,076,759
1885	1,919,063	790,332	326,456	265,381	3,301,232
1886	1,980,656	930,787	333,849	323,643	3,568,935
1887	1,791,531	1,039,692	329,561	504,619	3,665,403
1888	....	....	....	....	....

TRANSPORTATION RATES.

Complying with the requirements of Congress, this Division has published, in each of its monthly statistical reports throughout the year, through and local rates of freight upon the principal products of agriculture and articles necessary for farm cultivation, from important points of shipment to large market centers, by rail and water; also the cost of transporting our surplus products to foreign countries. The rates presented were those in operation upon the first day of each month, and do not show the fluctuations between the reports.

The through rates, Chicago to New York and other sea-board cities, have been much lower during the past year than those for 1887. They were very steady and well maintained until about June 1, when there seemed to be a tendency toward a rate war, which continued more or less throughout the remainder of the year.

For comparison, the following table is presented, showing the rates per 100 pounds from Chicago to New York upon the first day of each month for the five years ending 1884 to 1888, inclusive:

Months.	Cattle, car-load.					Sheep, car-load.					Hogs, car-load.				
	1884.	1885.	1886.	1887.	1888.	1884.	1885.	1886.	1887.	1888.	1884.	1885.	1886.	1887.	1888.
	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts	Cts.	Cts.	Cts.	Cts.
January 1	60	40	25	35	35	60	50	25	45	40	35	30	30	35	30
February 1	60	40	25	35	35	60	50	25	45	40	35	30	30	35	30
March 1	60	40	35	35	35	60	50	45	45	40	35	30	30	35	30
April 1	60	40	35	35	35	60	50	45	45	40	20	25	30	35	30
May 1	60	40	35	35	35	60	50	45	40	40	20	25	30	35	30
June 1	50	30	35	35	25	50	40	45	40	25	20	25	30	35	30
July 1	30	25	35	35	16½	40	40	45	40	25	25	20	30	30	30
August 1	30	25	35	35	5½	40	40	45	40	25	30	25	30	30	18
September 1	20	25	35	35	10	40	40	45	40	25	30	25	30	30	18
October 1	20	25	35	35	15	40	40	45	40	25	30	25	30	30	18
November 1	20	25	35	35	15	40	40	45	40	25	30	25	30	30	30
December 1	20	25	35	16½	15	40	40	45	19	25	30	30	30	30	25

Months.	Grain and flour, car-load.					Lard and pork, car-load.					Dressed beef, car-load.				
	1884.	1885.	1886.	1887.	1888.	1884.	1885.	1886.	1887.	1888.	1884.	1885.	1886.	1887.	1888.
	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.
January 1	30	25	25	30	27½	35	30	30	35	33	64	70	43½	65	65
February 1	30	25	25	30	27½	35	30	30	35	33	64	70	43½	65	65
March 1	30	25	25	30	27½	35	30	30	35	33	64	70	65	65	65
April 1	15	20	25	30	25	20	25	30	35	30	64	70	65	65	65
May 1	15	20	25	25	25	20	25	30	30	30	64	70	65	65	65
June 1	15	20	25	25	25	20	25	30	30	30	48	70	65	65	65
July 1	20	15	25	25	25	25	25	30	30	30	48	43½	65	65	26½ to 40
August 1	25	20	25	25	25	30	25	30	30	18	48	43½	65	65	7
September 1	25	20	25	25	25	30	25	30	30	18	32	43½	65	65	25
October 1	25	20	25	25	20	30	25	30	30	18	32	43½	65	65	35
November 1	25	20	25	25	20	30	25	30	30	30	32	43½	65	65	35
December 1	25	25	25	25	20	30	30	30	30	25	32	43½	65	31	35

It will be seen by the above table that live cattle and dressed beef were the articles affected the most by this fight, and that the rates on this traffic were lower then they have been for the past five years at least, if not ever before. Grain, flour, and live-sheep rates were not affected but remained steady at 25 cents, while the rates upon live hogs and hog products fell from 30 cents July 1, to 18 cents August 1, advanced to 30 cents November 1, and fell to 25 cents December 1.

The following statement shows the average rates of freight upon corn and wheat from Chicago to New York, via the three great routes, lake and canal, lake and rail, and all rail, for the twelve years 1876 to 1887 inclusive.

It will be seen that while the rates for 1887 were lower than those for 1886, they were higher than they were in 1885. The rates for 1885 were lower than for a great many years, with the exception of the *all rail* rates, which were the same as for 1884.

Years.	Corn.			Wheat.		
	By lake and canal.	By lake and rail.	By all rail.	By lake and canal.	By lake and rail.	By all rail.
	Cents.	*Cents.*	*Cents.*	*Cents.*	*Cents.*	*Cents.*
1876	8.75	10.79	15.74	9.82	11.36	16.86
1877	9.59	14.06	18.90	11.09	15.46	20.50
1878	8.83	10.53	16.52	9.96	12.09	17.70
1879	10.49	12.20	14.56	11.87	13.13	17.74
1880	13.41	14.43	17.48	13.13	15.80	19.80
1881	7.77	9.42	13.40	8.67	10.49	14.40
1882	6.72	10.28	13.50	7.23	10.91	14.47
1883	8.03	11.00	15.12	9.01	11.63	16.20
1884	6.55	8.50	12.32	7.00	10.00	13.20
1885	6.30	8.01	12.32	6.54	9.02	13.20
1886	8.45	11.20	14.00	9.10	12.00	15.00
1887	7.83	11.20	14.70	8.52	12.00	15.75

The following statement shows the weekly range of freights on wheat and corn, Chicago to Buffalo, Buffalo to New York, and Chicago to New York, via lakes and Erie Canal, for the years 1887 and 1888:

[In cents per bushel.]

Week ended—	Lake, Chicago to Buffalo.				Erie Canal, Buffalo to New York.				Chicago to New York, lake and canal.			
	1887.		1888.		1887.		1888.		1887.		1888.	
	Wheat.	Corn.	Wheat.	Corn.	Wheat.	Corn.	Wheat.	Corn.	Wheat.	Corn.	Wheat.	Corn.
May 10	3¼	3	2	1¾	6¼	5⅝	5	......	9½	8¾	7	......
17	3¼	3	2	1⅝	5	4⅝	3	2⅞	8¼	7⅝	5	4½
24	3½	3¼	2¼	2	4½	4⅛	2⅞	2⅝	8	7⅞	5⅛	4⅝
31	3¾	3½	2¼	2	4¼	4	3½	3	8	7½	5¼	5
June 7	4¼	4	....	2	4⅛	3⅞	3⅝	3¼	8⅝	7⅞	....	5⅛
15	5	4	2	1½	4¾	4¼	2¾	2½	9¾	8¼	4¾	4
22	6	5½	1⅝	1½	5	4½	2⅛	1⅞	11	10	3⅞	3⅝
30	5¼	4¾	2¼	2	4	3½	2⅛	2	9¼	8¼	4⅜	4
July 7	4¼	4	2¼	2	4	3⅝	2½	2	8¼	7⅝	4½	4
14	4	3⅝	1⅝	1½	4	3⅝	2½	2¼	8	7⅜	4¼	3⅝
22	3½	3¼	....	2	3¾	3⅝	2⅜	2½	7¼	6⅝	....	4½
29	3	2¾	....	2¼	3¾	3⅜	2⅝	2⅜	6¼	6⅛	....	4⅝
Aug. 7	3¼	3	2¾	2⅛	4	3⅝	3½	3¼	7¼	6⅝	6¼	5¾
15	3¼	3	3	2¾	3⅞	3½	4¼	4	7⅛	6½	7¼	6¾
23	3⅞	3⅝	3¼	3	3⅞	3½	4⅝	3⅞	7¾	7⅛	7⅝	6⅞
30	4½	4	3¼	3	3⅝	3½	4½	3⅝	8¼	7⅛	7⅜	6¾
Sept. 7	4⅝	4	3½	3¼	4	3⅝	3⅞	3½	8⅜	7⅝	7⅜	6¾
15	4	3¾	3⅝	3½	3¾	3½	3½	3¼	7¾	7¼	7¼	6¾
22	4	3¾	3¾	3½	4	3¾	4	3⅝	8	7½	7¾	7⅛
29	4	3¾	8¼	3	4	3⅝	3⅝	3½	8	7½	7	6⅛
Oct. 7	4	3¾	3	2½	4¼	4	3⅝	3¼	8¼	7¾	6¾	5¾
14	4¼	4	2½	2¼	4¼	4	3⅞	3⅜	8½	8	6¼	5⅝
22	5½	5	2¼	2	5	4½	3⅝	3¼	10½	9½	6	5¼
29	5½	5	2¼	2	4¾	4⅝	4	3⅝	10¼	9⅝	6¼	5⅝
Nov. 7	4¾	4½	2¾	2⅛	4¾	4½	4⅛	3¾	9½	9	6⅞	5⅞
15	2¾	2	2¼	2	5½	5	2⅝	2½	8¼	7	5	4½
22	....	3	2	1¾	6¾	6	4¼	3½	....	9	6¼	5¼
30	....	4½	....	4	....	....	....	....	....	....	....	....

TRANSATLANTIC RATES.

The cost of transporting our surplus wheat to foreign markets during the year 1888 fluctuated greatly. The average rate for the month of January for carrying wheat from New York to Liverpool was 4.83 cents per bushel. This average decreased monthly until April, when the rate was lower than at any time during the year.

The average for the year was 5.34 cents, which was a slight decrease from the year before, and the lowest average since 1866. The rates given are steamer rates, no business being done by sailing vessels.

Average cost per bushel for transporting wheat from New York to Liverpool, from 1866 to 1888, inclusive.

[Pence reduced to cents at 2 cents per penny.]

Years.	Steamer rates.		Years.	Steamer rates.	
	Pence.	*Cents.*		*Pence.*	*Cents.*
1866	4.74	9.48	1878	7.61	15.22
1867	5.18	10.36	1879	6.20	12.40
1868	7.18	14.36	1880	5.88	11.76
1869	6.40	12.98	1881	4.08	8.16
1870	5.78	11.56	1882	3.87	7.74
1871	8.16	16.32	1883	4.54	9.08
1872	7.64	15.28	1884	3.40	6.80
1873	10.56	21.12	1885	3.60	7.20
1874	9.08	18.16	1886	3.46	6.92
1875	8.07	16.14	1887	2.71	5.42
1876	8.02	16.04	1888	2.67	5.34
1877	6.93	13.86			

Average monthly prices paid for carrying grain from New York to Liverpool for five years.

Months.	1884.		1885.		1886.		1887.		1888.	
	Pence.	*Cents.*	*Pence.*	*Cents.*	*Pence.*	*Cents.*	*Pence.*	*Cents.*	*Pence.*	*Cents.*
January	2.35	4.70	5.33	10.66	3.37	6.75	4.91	9.83	2.41	4.83
February	2.24	4.48	4.41	8.83	2.33	4.66	3.66	7.33	1.83	3.66
March	1.56	3.12	3.33	6.66	2.41	4.83	3.16	6.33	.83	1.66
April	1.77	3.54	3.83	7.66	3.66	7.33	1.50	3.00	.43	.87
May	1.25	2.50	3.66	7.33	3.79	7.58	1.58	3.16	.62	1.25
June	3.08	6.16	2.75	5.50	4.75	9.50	2.12	4.25	1.66	3.33
July	4.71	9.42	2.41	4.83	2.83	5.66	2.62	5.25	1.75	3.50
August	4.68	9.36	2.33	4.66	1.83	3.66	3.00	6.00	2.33	4.66
September	3.00	6.00	3.16	6.33	2.66	5.33	1.83	3.66	5.33	10.66
October	4.00	8.00	4.00	8.00	4.00	8.00	2.00	4.00	4.50	9.00
November	5.79	11.58	3.50	7.00	4.25	8.50	3.50	7.00	4.50	9.00
December	6.37	12.74	2.66	5.33	4.66	9.33	3.00	6.00	5.87	11.75

AGRICULTURAL EXPORTS AND IMPORTS.

Exports of the products of domestic agriculture, 1887 and 1888.

Articles.	1887.		1888.	
	Quantities.	Value.	Quantities.	Value.
Animals, living:				
Cattle ....number	106,459	$9,172,136	140,208	$11,577,578
Hogs ....do	75,383	564,753	23,755	193,017
Horses ....do	1,611	351,607	2,263	412,774
Mules ....do	1,754	214,738	2,971	378,765
Sheep ....do	121,701	254,725	143,817	280,490
All other, and fowls	....	40,403	....	42,466
Animal matter:				
Bones, hoofs, horns and horn tips, strips, and waste	....	162,958	....	193,176
Casings for sausages	....	538,236	....	766,186
Eggs ....dozen	372,772	60,686	419,701	66,724
Glue ....pounds	275,362	39,773	356,899	46,773
Grease, grease scraps, and all soap stock	....	849,908	....	924,777
Hair and manufactures of	....	335,548	....	311,279
Hides and skins other than furs	....	765,655	....	673,322

Exports of the products of domestic agriculture, 1887 *and* 1888—Continued.

Articles.	1887.		1888.	
	Quantities.	Value.	Quantities.	Value.
Animal matter—Continued.				
Honey		$67,154		$7,579
Oils:				
Lard ... gallons	975,163	519,274	930,616	509,514
Other animal ... do	570,376	291,396	617,737	414,622
Provisions, comprising meat and dairy products:				
Meat products—				
Beef products—				
Beef, canned ... pounds	43,050,588	3,462,982	40,458,375	3,339,077
Beef, fresh ... do	83,560,874	7,223,412	93,498,273	8,231,281
Beef, salted or pickled ... do	36,287,188	1,972,246	48,980,269	2,608,479
Beef, other cured ... do	192,191	17,942	83,151	8,579
Tallow ... do	63,278,403	2,836,300	92,483,052	4,252,653
Mutton ... do	371,572	18,397	224,738	18,641
Oleomargarine—				
Imitation butter ... do	834,574	88,848	1,729,327	212,634
The oil ... do	45,712,985	4,676,131	30,146,595	3,230,123
Pork products—				
Bacon ... do	364,417,744	27,338,943	331,306,703	27,187,175
Hams ... do	55,505,211	5,975,727	44,132,980	4,988,458
Pork, fresh ... do	23,930	1,233	63,187	4,423
Pork, salted or cured ... do	85,869,367	5,640,094	58,836,966	4,368,691
Lard ... do	321,533,746	22,703,921	297,740,007	22,751,105
Poultry and game		28,284		25,496
All other meat products		956,534		915,247
Dairy products—				
Butter ... do	12,531,171	1,983,698	10,455,651	1,884,908
Cheese ... do	81,255,994	7,594,633	88,008,458	8,736,304
Milk		258,971		294,806
Wax, bees' ... do	90,350	24,997	78,070	20,554
Wool, raw ... do	257,940	78,002	22,164	5,272
Total value of animals and animal matter		107,115,245		109,882,948
Bread and breadstuffs:				
Barley ... bushels	1,305,300	853,405	550,884	317,239
Bread and biscuit ... pounds	15,060,061	659,924	13,948,708	658,589
Indian corn ... bushels	40,307,252	19,347,361	24,278,417	13,355,950
Indian corn meal ... barrels	265,333	705,343	270,613	765,036
Oats ... bushels	440,283	179,634	332,564	143,284
Oatmeal ... pounds	16,818,330	456,023	4,329,293	130,488
Rye ... bushels	357,256	216,190	78,783	50,705
Rye flour ... barrels	3,341	11,781	2,674	10,068
Wheat ... bushels	101,971,949	90,716,481	65,789,261	56,241,468
Wheat flour ... barrels	11,518,449	51,950,028	11,963,574	54,777,710
All other breadstuffs and preparations of, used as food		672,384		741,150
Total value of bread and breadstuffs		165,768,662		127,191,687
Cotton and cotton-seed oil:				
Cotton—				
Sea-island ... pounds	8,021,497	1,798,272	7,053,765	1,672,828
Other unmanufactured ... do	2,161,435,833	204,423,785	2,257,067,061	221,343,932
Cotton-seed oil ... gallons	4,067,138	1,578,935	4,458,507	1,925,739
Total value of cotton and cotton-seed oil		207,800,992		224,942,499
Miscellaneous:				
Broom corn		170,534		160,651
Fruits and nuts—				
Apples, dried ... pounds	8,130,396	413,363	11,803,161	812,682
Apples, green or ripe ... barrels	591,868	1,382,872	489,570	1,378,801
Fruits, preserved—				
Canned		506,794		834,668
Other		29,489		58,630
All other, green, ripe, or dried		337,447		397,643
Nuts				27,784
Hay ... tons	13,873	218,006	18,198	328,819
Hops ... pounds	260,721	54,970	6,793,818	1,208,060
Oil cake and oil-cake meal ... do	622,295,233	7,309,691	562,744,209	6,423,930
Oils:				
Linseed ... gallons	119,840	57,136	92,134	52,049
Other vegetable		65,689		56,890
Rice ... pounds	644,384	29,204	398,535	22,234
Seeds:				
Clover ... do	7,932,390	630,850	13,357,899	1,009,695
Cotton ... do	11,232,141	121,441	6,218,555	84,195

Exports of the products of domestic agriculture, 1887 *and* 1888—Continued.

Articles.	1887.		1888.	
	Quantities.	Value.	Quantities.	Value.
Miscellaneous—Continued.				
Seeds—Continued.				
Flaxseed or linseed..........bushels..	....	....	37,265	$41,155
Timothy....................pounds..	6,500,004	$281,048	2,097,197	117,677
All other..................................	....	874,070	....	263,968
Tobacco:				
Leaf............................do....	293,666,995	25,637,983	249,195,681	21,507,776
Stems and trimmings ....do....	11,253,128	310,294	13,487,140	428,308
Vegetables:				
Onions ....bushels..	71,689	73,515	56,725	64,161
Peas and beans................do....	387,222	562,864	253,170	462,762
Potatoes.......................do....	434,864	318,259	403,880	308,193
Vegetables, canned........................	....	228,507	....	265,537
All other, including pickles	....	125,448	....	140,634
Wine:				
In bottles ....dozens..	4,426	23,499	7,185	31,698
Not in bottles ....gallons..	282,607	191,672	302,233	201,525
All other agricultural products	....	181,154	....	263,770
Total value of miscellaneous products..	....	40,135,859	....	36,948,895
RECAPITULATION.				
Total value of animals and animal matter ...	....	107,115,245	....	109,882,948
Total value of bread and breadstuffs	....	165,768,662	....	127,191,687
Total value of cotton and cotton-seed oil	....	207,800,992	....	224,942,499
Total value of miscellaneous products	....	40,135,859	....	36,948,895
Total agricultural exports	....	520,820,758	....	*498,966,029
Total exports of domestic manufacture	....	703,022,923	....	683,862,104
Per cent. of agricultural matter	....	74	....	73

* In this compilation of domestic agricultural exports sugar and molasses are not included, because they are mainly re-exports of foreign production. The totals differ from those given by the Bureau of Statistics of the Treasury Department, they having included sugar and molasses, "ginseng and roots, herbs, and barks not otherwise specified," and "glucose or grape sugar".

Imports of agricultural products, 1887 *and* 1888.

Articles.	1887.	1888.
Sugar and molasses:		
Sugar..	$78,411,224	$74,245,206
Molasses	5,355,475	5,491,095
Total sugar and molasses..............................	83,766,699	79,736,301
Tea, coffee, and cocoa:		
Tea	16,771,802	13,360,685
Coffee	56,347,600	60,507,630
Cocoa	1,670,012	2,251,773
Total tea, coffee, and cocoa	74,789,414	76,120,088
Animals and their products:		
Cattle	1,392,032	875,998
Horses	4,872,982	5,405,863
Sheep	1,245,782	1,366,320
All other, and fowls.....................................	305,402	358,204
Bristles..	1,174,333	1,215,325
Butter..	38,125	26,429
Cheese	874,261	1,214,936
Eggs	1,960,396	2,312,478
Hair	2,617,156	2,303,485
Hides	24,219,101	23,939,339
Meats—		
Preserved	272,651	317,235
All other	162,202	154,619
Milk, preserved or condensed..............................	459,000	376,062
Oil, animal..	3,387	3,744
Wools	16,424,479	15,887,217
Total animals and their products.........................	56,021,289	55,757,254

Imports of agricultural products, 1887 *and* 1888—Continued.

Articles.	1887.	1888.
Miscellaneous:		
Breadstuffs:		
Barley	$6,173,208	$8,076,082
Indian corn	16,636	20,507
Oats	29,579	23,655
Oatmeal	37,857	37,515
Rye	10,720	20
Wheat	218,867	466,886
Wheat flour	3,302	13,257
All other breadstuffs and preparations of, used as food, not elsewhere specified	150,059	117,870
Cotton	533,928	744,800
Farinaceous substances, etc., not elsewhere specified	721,404	905,991
Flax, hemp, jute, etc., unmanufactured:		
Flax	1,922,182	1,802,089
Hemp and all substitutes	4,041,522	6,934,837
Jute	2,616,128	3,377,369
Sisal-grass and other vegetable substances	3,733,001	5,430,894
Fibers not elsewhere specified		318,133
Fruits and nuts	20,608,486	20,502,223
Hay	790,394	979,524
Hops	3,404,669	1,017,495
Malt, barley	153,363	164,585
Oils, vegetable:		
Fixed or expressed—		
Olive	662,197	617,172
Other	1,023,059	316,212
Volatile or essential	1,012,819	141,554
Rice	2,060,379	3,012,961
Seed	1,448,307	2,833,421
Silk, unmanufactured*	19,642,797	19,931,682
Spices:		
Ground	168,760	187,677
Unground—		
Nutmegs	539,291	603,556
Pepper	1,819,609	1,823,239
All other	953,752	914,773
Tobacco, leaf	8,704,950	10,870,841
Vegetables:		
Beans and peas	607,853	2,190,137
Potatoes	543,091	3,693,021
Pickles and sauces	387,177	416,958
All other—		
In their natural state or in salt or brine	516,319	715,063
Prepared or preserved	295,911	350,245
Wines:		
Champagne and other sparkling	3,382,907	3,646,475
Still wines—		
In casks	2,345,565	2,287,062
In bottles	1,327,613	1,402,661
Total miscellaneous	72,964,864	106,888,442
RECAPITULATION.		
Sugar and molasses	83,766,699	79,736,301
Tea, coffee, and cocoa	74,789,414	76,120,088
Animals and their products	56,021,289	55,757,254
Miscellaneous	72,964,864	106,888,442
Total imports of agricultural products	287,542,266	318,502,085

*Included for the first time.

STATISTICS OF JAPAN.

Publications of the Bureau of Statistics of Japan, prepared under the direction of S. Ishibashi, are acknowledged. A statistical annual is published and a condensation is issued in Japanese and French for foreign circulation. This nation exhibits remarkable enterprise in statistics, setting an example to some of the European states that are scarcely as progressive in this direction.

POPULATION.

On the 31st of December, 1886, the population of the Empire embraced 38,507,177 persons, 19,451,491 being males and 19,055,686 females. On the 1st of January, 1879, the population was 35,768,584, the increase since that date being 2,738,593. Of the population on the 31st of December, 1886, 3,430 were of noble rank; 1,940,271 of the samourai, or former warrior caste; and 36,563,476 of the commonalty. The average number of deaths per 1,000 inhabitants in 1886 was 24.4; the number of births 27.3; the number of marriages 8.19; and the number of divorces 3.06. The high divorce rate is especially noticeable. The average number of persons to each household on December 31, 1886, was 4.97. The average density of the population at the same date was 261 to the square mile.

TERRITORIAL AREA.

The total area of the Empire is set down as 24,794.36 square ri, or 147, 655 square miles. The area of taxable real property is stated as follows:

Description.	Square tcho.	Acres.
Rice plantations	2,640,986.2	6,472,265
Fields	1,885,908.8	4,621,797
Lands with buildings on them	354,515.4	868,811
Forests	7,186,918.6	17,612,981
Other lands	1,009,723.9	2,474,530
Total	13,078,052.9	32,050,384

The distribution of cereal crops in 1885 is thus given:

Crops.	Area.		Product.	
	Square tcho.	Acres.	Kokou.	Bushels.
Rice	2,611,987.0	6,401,197	34,158,169	169,523,577
Wheat, barley, and rye	1,534,091.7	3,759,599	11,935,467	59,234,529

The average rate of yield is as follows: Rice, 1.31 kokou per tan, or 26.53 bushels per acre; wheat, barley, and rye, taken together, 0.78 kokou per tan, or 15.79 bushels per acre.

To the table from which these figures are obtained the remark is appended that the returns which form the basis of the figures on production are a little below the truth.

The extent of the forests and of mountain and uncultivated lands belonging to the state in 1884 is stated as follows:

Description.	Square tcho.	Acres.
Forests	5,576,595.3	13,666,562
Mountains and uncultivated lands	12,059,847.5	29,555,068

FARM ANIMALS.

The number of cows on the 31st of December, 1885, is stated as 617,676, and the number of oxen as 442,494, making the total of cows and oxen 1,060,170.

The number of horses at the same time was 697,286, that of mares 850,946, and the total of horses and mares 1,548,232.

SILK PRODUCTION.

The products of silk reported for 1885 (the year for which production is reported in the subsequent paragraphs) are as follows:

Description.	Kwan.	Pounds.
Raw silk	561,010	4,646,117
Raw silk (inferior quality)	141,411	1,171,123
Floss silk	50,518	418,375

	Number.
Cards of silk-worm eggs	1,113,014

The statement is made in this connection that the product of raw silk given in the official document represents about the amount of the exports of that commodity to Europe and America, and the opinion is expressed that if the quantity consumed in the interior were included, it would raise the total product to 800,000 or 900,000 kwan, or 6,625,360 to 7,453,530 pounds.

PRODUCTION OF TEA.

The official figures, as given in kwan, with their equivalent in pounds, are presented below:

	Kwan.	Pounds.
Product of tea in 1885	2,988,957	24,753,645
Product of tea called "Bantcha"	2,488,971	20,612,911
Total	5,477,928	45,366,556

The statement is made in this connection in the official report that while the production here reported is but little in excess of the amount of the tea exported, the domestic consumption of tea is very large, and is general among all classes of the Japanese people. The actual production must therefore be much larger than the above figures would make it.

PRODUCTION OF SUGAR.

Description.	Kwan.	Pounds.
Cane sugar:		
Raw	9,552,640	79,112,099
Refined	2,005,838	16,611,748
Total	11,558,478	95,723,847
From Chinese sugar-cane:		
Raw	15,289	126,619
Refined	109	903
Total	15,398	127,522

Of beet sugar there was a product of 81,728 kwan, or 676,847 pounds, all raw.

It is stated that information as to sugar production is lacking for many locations, and that the figures presented are consequently below the truth.

PRODUCTION OF SAKE.

The number of distilleries, breweries, etc., producing sake for sale is stated at 16,425, and the number of manufacturers at 16,184. The production for sale was as follows:

Description.	Kokou.	Gallons.
Common sake	2,576,783	102,306,788
Distilled spirit	42,814	1,699,857
Other kinds of sake	60,854	2,416,105

For several years previous to 1883 the production of sake was much larger than at present. The decrease is attributed to the fact that in the year named the tax on sake was raised from 2 yen to 4 yen per kokou (about 5 cents to 10 cents per gallon).

The tax on sake made exclusively for household use is only 80 sen (four-fifths of a yen) per kokou (2 cents per gallon), but the quantity which may be made at this rate is limited to less than 1 kokou (39.7033 gallons) to a household. The number of persons who manufactured sake under this provision was 692,103, and the quantity produced was 572,995 kokou, or 22,749,792 gallons.

WAGES.

The average daily wages in agriculture without board for 1885 is stated at 0.186 yen (18.6 cents) for men, and 0.121 yen (12.1 cents) for women. The average monthly wages with board is set down at 2.117 yen ($2.117) for men, and 1.199 yen ($1.199) for women. Workmen employed in the preparation of tea receive 0.253 yen (25.3 cents) a day, and day laborers 0.199 yen (19.9 cents). In domestic service men receive on an average 1.889 yen ($1.889) per month, and women 1.056 yen ($1.056) per month, with board.

EXPORTS AND IMPORTS.

The annual aggregates of value for 1886 are—

Japanese products exported	$47,997,957
Foreign products imported	37,568,454

Including foreign articles re-exported the total exports amounted to $48,870,472, of which value $1,528,751 represented coal and other supplies for ships, leaving $47,341,721 as the value of commodities exported to various foreign countries. The total imports, including Japanese articles re-imported, amounted to $37,637,138.

Production is encouraged, and exports of domestic products are increasing. In 1880 the balance of trade was against Japan about 9,000,000 yen; now exports are about 10,000,000 yen in excess of imports. The imports of 1880 and 1886 were nearly the same, but the exports increased in six years 68 per cent.

The country having the largest share in the foreign trade of Japan is the United States, Great Britain standing next in order. The values of the exports to and imports from these and other important countries are stated below.

Countries.	Exports.	Imports.
United States	$19,988,217	$4,258,038
Great Britain	4,195,356	16,012,055
China	9,594,907	7,123,851
France	9,632,903	1,665,297
Germany	864.459	2,974,679

It will be observed that the exports to the United States are nearly five times as great as the imports therefrom, while the imports from Great Britain are nearly four times as large as the exports to that country. In the trade with France, again, the exports are nearly six times as large as the imports, while in the trade with Germany the imports are more than three times as large as the exports. In the trade with China there is some approach to an equality between the imports and the exports.

Of the 47,997,957, yen (or dollars') worth of Japanese products exported in 1886, more than one-half in value consisted of raw silk and green tea, the former amounting to 17,321,362 yen and the latter to 7,511,864 yen, or both together to 24,833,226 yen. Floss silk, silk waste, silk fabrics, etc., amounted to 3,201,881 yen, rice to 3,300,863 yen, pit coal to 2,208,549 yen, copper, raw and worked, to 2,148,841 yen, porcelain and pottery to 1,034,139 yen, and lacquered ware to 589,170 yen.

Of the imports, spun cotton amounted to 5,905,457 yen, sugar to 5,557,013 yen, petroleum to 2,358,498 yen, iron in rods to 1,209,713 yen, other metals to 1,328,258 yen, and manufactures of metal to 562,113 yen, while the various textile fabrics of cotton, linen, wool, and silk amounted in the aggregate to 7,018,997 yen.

A comparison of 1886 with 1882 shows an increase of 14.9 per cent. to have taken place in the imports and an increase of 28.2 per cent. in the exports since that year.

RAILROADS, TELEGRAPHS, ETC.

In 1885–'86 there were 410 miles of railroad. The number of passengers carried in 1876–'77 was 2,931,855; in 1885–'86, 4,067,970. Total receipts in the same time advanced from 1,284,466 yen (the Japanese dollar) to 1,490,393 yen.

The lines of telegraph aggregate a length of 2,217 miles at the former date, and 5,779 at the latter, showing remarkable increase in nine years. The increase of telegrams sent was from 617,077 to 1,700,282.

The postal savings-banks numbered 161 in 1876, 1,469 in 1884, and 4,338 in 1885. The amount deposited increased from $58,350 in 1876 to $12,022,317 in 1885, of which $8,665,424 remained on deposit at the end of the year. The number of depositors was 344,921. In this feature Japan is in advance of the United States.

The number of post-offices was 4,137 in 1885; there were 29,438 miles of post-roads; and there were 97,216,019 letters transmitted, besides newspapers, books, and merchandise.

There is also a money-order system, with 886 offices; 833,300 orders were issued in 1885, amounting to $7,110,531.

EGYPTIAN AGRICULTURE.

The area in crops in Egypt is comparatively small. Less than an acre per capita is annually cultivated. Egypt contains about 175,000 square miles, much of the territory a desert. The area used for crops is only available by irrigation, natural or artificial, the main dependence being the annual overflow of the Nile. But little over 5,000,000 acres are in cultivation, less than one to each head of population. The population of Egypt is as follows, exclusive of the oases and the governorats (Cairo, Alexandria, Damietta, Rosetta, Port Said, Suez, El Arish, and Kosseir):

Description of population.	Lower Egypt.	Upper Egypt.	Total.
Agricultural	2,281,984	1,917,687	4,199,671
Non-agricultural	983,597	806,269	1,789,866
Total	3,265,581	2,723,956	5,989,537

A recent official report, based on the replies to a circular of which 15,000 copies were addressed to the *sheiks el beled* throughout Egypt, has been summarized in the French language, and furnishes some interesting data in regard to crop areas and numbers of farm animals in that country. The following table shows the areas devoted to the different crops, as expressed in feddans and in acres, with the percentage under each crop or class of crops specified:

Areas under the different crops in 1887.

Crops.	Lower Egypt.		Upper Egypt.		Total.		Percentage of total area.
	Feddans.	*Acres.*	*Feddans.*	*Acres.*	*Feddans.*	*Acres.*	
Wheat	617,605	641,136	623,495	647,250	1,241,100	1,288,386	20.23
Clover	593,236	615,838	347,986	361,244	941,222	977,083	15.34
Cotton	797,337	827,716	68,189	70,787	865,526	898,503	14.11
Beans	304,873	316,489	450,995	468,178	755,868	784,667	12.32
Maize	570,393	592,125	113,434	117,756	683,827	709,881	11.15
Barley	317,523	329,621	202,828	210,556	520,351	540,176	8.48
Doura	124,867	129,624	316,428	328,484	441,295	458,108	7.19
Lentils	8,344	8,662	141,773	147,175	150,117	155,836	2.45
Rice	145,158	150,689	4,559	4,733	149,717	155,421	2.44
Fenugreek	27,561	28,611	103,113	107,042	130,674	135,653	2.13
Pot-herbs, onions, etc	32,340	33,572	46,729	48,509	79,069	82,082	1.29
Sugar-cane	5,573	5,785	65,630	68,131	71,203	73,916	1.16
Vetches	....	....	31,536	32,738	31,536	32,738	.52
Melons and cucumbers	6,395	6,639	14,369	14,916	20,764	21,555	.34
Lupines, etc	1,641	1,704	11,735	12,182	13,376	13,886	.22
Tobacco	2,450	2,543	9,207	9,558	11,657	12,101	.19
Chick peas, kidney beans, etc.	2,468	2,562	8,483	8,806	10,951	11,368	.18
Flax	4,772	4,954	1,604	1,665	6,376	6,619	.10
Sesame, castor beans	1,909	1,982	3,049	3,165	4,958	5,147	.08
Henneh	1,640	1,702	54	56	1,694	1,759	.03
Carthamus, or safflower	....	....	1,316	1,366	1,316	1,366	.02
Pea-nuts	1,205	1,251	5	5	1,210	1,256	.02
Indigo	6	6	275	285	281	292	.01
Poppies	....	....	276	287	276	287	
Total	3,567,296	3,703,211	2,567,068	2,664,874	6,134,364	6,368,086	100.00
Vines and fruit trees	5,164	5,361	3,582	3,718	8,746	9,079	....

The cereals and other food-crops for man and beast occupy by far the larger part of the total crop area, but the principal crops pro-

duced for the market are cotton and sugar-cane, the first of which is cultivated chiefly in Lower and the second almost exclusively in Upper Egypt, where it is confined to certain districts in which there are sefi (summer) canals.

The areas embraced in the above table represent in part land on which more than one crop was grown during the year, and though the crops specified occupied an aggregate area of 6,134,364 feddans, they were actually grown on 4,961,462 feddans of cultivated land. The operations of Egyptian agriculture are arranged with reference to three seasons, Chitwi, Sefi, and Eili, each of which has its appropriate crops.

In the French summary of the report above referred to these words are respectively rendered by the words *hiver*, *été*, and *automne* (winter, summer, and autumn), but it is more specifically stated that Chitwi extends from October to May, Sefi from April to October, and Nili from August to October, from which it appears that there is considerable overlapping between some of the crops of different seasons.

The dates for the agricultural work of the different seasons, and the times within which the seasons respectively end, are stated as follows:

Seasons.	Tillage.	Sowing.	End of seasons.
Chitwi	Beginning of November	Middle of November	May–July.
Sefi	End of November	End of March	October–November.
Nili	July	July	September–October.

From this statement it would seem that the gathering of the different crops of each season extends over a considerable period, according to their respective times of ripening, etc.

The following table shows for each of the three seasons the portions of the total area of cultivated land under crop and the portions not so occupied:

Seasons.	Territorial divisions.	Under crop.			Cultivated area not under crop.		
		Feddans.	Acres.	Per cent. of total.	Feddans.	Acres.	Per cent. of total.
Chitwi	Lower Egypt	1,948,690	2,022,935	71.02	795,300	825,601	28.98
	Upper Egypt	2,005,776	2,082,196	90.45	211,696	219,762	9.55
	Total	3,954,466	4,105,131	79.70	1,006,996	1,045,363	20.30
Sefi	Lower Egypt	1,017,557	1,056,326	37.09	1,726,433	1,792,210	62.91
	Upper Egypt	283,668	294,476	12.79	1,933,804	2,007,482	87.21
	Total	1,301,225	1,350,802	26.22	3,660,237	3,799,692	73.78
Nili	Lower Egypt	601,049	623,949	21.90	2,142,941	2,224,587	78.10
	Upper Egypt	277,624	288,201	12.52	1,939,848	2,013,756	87.48
	Total	878,673	912,150	17.70	4,082,789	4,238,343	82.30

Adding the area under crop during any one of the three seasons to the area of cultivated land not then under crop, but cropped in at least one of the other two seasons, we obtain the following as the total area of cultivated land for the year; that is, of land which was under crop in at least one of the three seasons:

Territorial divisions.	Feddans.	Acres.
Lower Egypt	2,743,990	2,848,536
Upper Egypt	2,217,472	2,301,958
Total	4,961,462	5,150,494

Calling this area 100, and placing it in comparison with the areas under Chitwi, Sefi, and Nili crops, and also with their sum, we have the following statement of areas in feddans and of the percentage which each area forms of the total area of cultivated land under crop within the year:

Crops, etc.	Lower Egypt.		Upper Egypt.		Total.	
	Area in feddans.	Per cent. of cultivated area.	Area in feddans.	Per cent. of cultivated area.	Area in feddans.	Per cent. of cultivated area.
Chitwi	1,948,690	71.02	2,005,776	90.45	3,954,466	79.70
Sefi	1,017,557	37.09	283,668	12.79	1,301,225	26.22
Nili	601,049	21.90	277,624	12.52	878,673	17.70
All	3,567,296	130.01	2,567,068	115.76	6,134,364	123.62
Total area of cultivated land.	2,743,990	100.00	2,217,472	100.00	4,961,462	100.00

This table shows that through raising more than one crop within the year on much of the land cultivated the total breadth of crops considerably exceeded the total area of cultivated land, the excess amounting to 30.01 per cent. in Lower Egypt to 15.76 per cent. in Upper Egypt, and to 23.62 per cent. on a general average for the whole country.

In the year 1887 the crops of the Nili season were destroyed over large areas in Upper Egypt by an unusual rise of the waters in the overflow of the Nile, but in Lower Egypt there seems to have been an unusual breadth of land under maize and doura, which contributed to maintain the average as regards the general production of the country.

The following table shows the area under each crop of the Sefi and Nili seasons. The sum of these two, increased by the crops of the Chitwi season, would make the totals given in the first table:

Seasons.	Crops.	Lower Egypt.		Upper Egypt.		Total.	
		Feddans.	*Acres.*	*Feddans.*	*Acres.*	*Feddans.*	*Acres.*
Sefi	Cotton	797,337	827,716	68,189	70,787	865,526	898,503
	Sugar-cane	5,085	5,279	65,009	67,486	70,094	72,765
	Doura (Baladi)	56,109	58,247	98,469	102,221	154,578	160,467
	Doura (Chami)	63,110	65,514	24,922	25,872	88,032	91,386
	Rice	77,629	80,587	416	432	78,045	81,018
	Sesame and flax	2,200	2,284	2,708	2,811	4,908	5,095
	Indigo	6	6	275	285	281	292
	Henneh	893	927	54	56	947	983
	Pea-nuts (*foul Soudani*)	1,205	1,251	5	5	1,210	1,256
	Pot-herbs, onions, etc	7,588	7,877	9,252	9,605	16,840	17,482
	Water-melons	6,395	6,639	14,369	14,916	20,764	21,555
	Total area of the Sefi crops.	1,017,557	1,056,326	283,668	294,476	1,301,225	1,350,802
Nili	Doura (Chami)	507,283	526,610	88,512	91,884	595,795	618,495
	Doura (Baladi)	67,640	70,217	171,157	177,678	238,797	247,895
	Rice	19,203	19,935	3,779	3,923	22,982	23,857
	Legumes	6,923	7,187	14,176	14,716	21,099	21,903
	Total area of the Nili crops.	601,049	623,949	277,624	288,201	878,673	912,150

FRUIT TREES AND VINES.

Fruit trees occupy but a limited area, and while they are productive, their cultivation for the purpose of marketing their produce does not, except in two or three provinces, form an important part of rural industry. The vine is found in nearly all the provinces, but is cultivated only on a small scale, though it is of late receiving increased attention. The most important vineyards are in Fayoum and in the province of Beherah, in Lower Egypt. Olives are cultivated in a few provinces.

The following tables show the number of the principal kinds of fruit trees and the area occupied by fruit trees and vines:

Number of fruit trees, not including isolated trees or trees on borders.

Kinds of trees.	Lower Egypt.	Upper Egypt.	Total.
Orange, mandarin, citron, etc.	837,078	59,367	896,445
Pomegranate	72,977	103,228	176,205
Fig, peach, apple, pear, apricot, etc	251,054	203,917	454,971
Total fruit trees, except date trees	1,161,109	366,512	1,527,621
Date trees * bearing seed or fruit	1,097,552	2,355,122	3,452,674
Grand total	2,258,661	2,721,634	4,980,295

* Exclusive of 278,000 producing date trees in the oases.

Area under vines and under fruit (other than date) trees.

[Measurements expressed in feddans and kerats. 1 kerat = $\frac{1}{24}$ feddan.]

Description.	Lower Egypt.	Upper Egypt.	Total.	
	Fds. Kts.	*Fds. Kts.*	*Fds. Kts.*	*Acres.*
Vines	748 01	780 07	1,528 08	1,587
Fruit (excluding date) trees	4,416 05	2,801 18	7,217 23	7,493
Total	5,164 06	3,582 01	8,746 07	9,080

Besides the kinds of fruits thus far mentioned there are many others which are cultivated for domestic consumption. These include bananas, Barbary figs, medlars, mangoes, mulberries, etc., "of which it is impossible to estimate the number of plants."

FARM ANIMALS.

The following table shows the number of farm animals:

Animals.	Lower Egypt.	Upper Egypt.	Total.
Cattle (excluding buffaloes)	129,207	81,008	210,215
Buffaloes	163,264	88,332	251,596
Camels	28,240	26,767	55,007
Horses	13,922	6,857	20,779
Mules	3,446	393	3,839
Asses	114,726	55,099	169,825
Sheep and goats	388,589	569,010	957,599
Total	841,394	827,466	1,668,860

Since 1884, in which year there were enormous losses from an epizootic, no serious disease of that character has prevailed among live-stock, and all the information collected shows a considerable increase in cattle. Hogs are but little raised, the consumption of their flesh being very small.

Poultry raising is very general, but it has not been possible to obtain the number of hens, chickens, turkeys, geese, ducks, guinea-fowls, etc. It is estimated that these, together with rabbits raised for consumption, will amount to a total of 6,000,000 head. Pigeons are quite numerous, being certainly in excess of 10,000,000 head. The raising of these birds is an important industry, not only for the sale of the birds themselves for consumption, but also for the manure which they supply, and which is much prized by cultivators.

EXPORTS AND AVERAGE PRICES OF COTTON.

By conversion of Egyptian denominations into their American equivalents, the following table, showing the exports of cotton and its average price in the Alexandria market for each year from 1821 to 1887, is obtained from one comprised in the official report above referred to, which, however, was compiled in part from commercial sources, a report of the Cotton Supply Association of Manchester being drawn upon for the figures on exportation from 1821 to 1859, inclusive:

Years.	Price per pound.	Pounds exported.	Years.	Price per pound.	Pounds exported.	Years.	Price per pound.	Pounds exported.
	Cents.			*Cents.*			*Cents.*	
1821	16.1	1,000,000	1844	18.1	15,000,000	1866	35.5	126,400,000
1822	15.6	3,400,000	1845	6.0	33,800,000	1867	22.7	128,700,000
1823	15.6	15,600,000	1846	10.3	19,800,000	1868	19.1	123,000,000
1824	17.1	22,400,000	1847	10.1	25,300,000	1869	23.2	126,500,000
1825	13.1	20,800,000	1848	7.3	11,800,000	1870	19.7	132,600,000
1826	13.1	21,200,000	1849	10.1	25,300,000	1871	15.9	192,900,000
1827	13.1	15,700,000	1850	11.8	35,800,000	1872	21.2	206,800,000
1828	13.1	5,800,000	1851	8.8	37,700,000	1873	18.7	197,500,000
1829	12.1	10,300,000	1852	10.3	65,700,000	1874	16.3	252,600,000
1830	12.1	21,000,000	1853	10.1	46,800,000	1875	15.1	216,400,000
1831	10.6	18,300,000	1854	9.1	46,900,000	1876	19.0	295,000,000
1832	15.1	13,400,000	1855	9.3	51,100,000	1877	18.8	239,300,000
1833	28.2	5,500,000	1856	10.8	53,000,000	1878	12.3	253,400,000
1834	31.0	14,100,000	1857	16.4	48,200,000	1879	13.7	164,800,000
1835	25.4	21,000,000	1858	12.9	51,000,000	1880	14.2	306,400,000
1836	18.6	23,900,000	1859	12.1	49,300,000	1881	14.5	273,900,000
1837	13.1	30,900,000	1860	12.3	49,200,000	1882	13.9	279,200,000
1838	15.1	23,400,000	1861	14.1	58,500,000	1883	15.1	225,000,000
1839	18.4	13,200,000	1862	23.2	70,700,000	1884	13.6	263,500,000
1840	13.1	15,600,000	1863	36.5	115,900,000	1885	12.6	352,300,000
1841	13.4	19,000,000	1864	45.4	168,600,000	1886	11.5	284,900,000
1842	10.1	20,700,000	1865	32.0	196,300,000	1887	12.1	296,800,000
1843	7.8	25,600,000						

PRODUCTION FROM SUGAR CANE IN THE DAÏRA SANIEH.

The manufactories of the Daïra Sanieh use about three-fourths of the sugar cane produced in Egypt. From a table showing in Egyptian denominations the quantities, values, and prices of the sugar (Nos. 1, 2, and 3) which they produced from 1877 to 1887, inclusive, the following statement in our denominations is derived:

Years.	Product.	Value.	Price per pound.		
			No. 1.	No. 2.	No. 3.
	Pounds.		*Cents.*	*Cents.*	*Cents.*
1877	82,247,400	$4,399,038	6.0	4.1	2.9
1878	87,315,100	3,964,009	5.0	3.3	2.5
1879	68,147,300	2,807,318	4.5	3.0	2.5
1880	75,834,900	3,582,039	5.2	3.4	2.8
1881	29,044,000	1,441,834	5.6	3.6	2.8
1882	71,496,200	3,301,494	5.1	3.4	2.7
1883	45,539,700	1,905,121	4.7	3.0	2.5
1884	82,632,600	2,900,379	4.2	1.8	1.6
1885	98,677,200	2,855,195	3.2	1.9	1.9
1886	111,493,800	2,946,745	2.9	1.9	1.6
1887	106,959,700	2,724,349	2.8	1.7	1.7

AGRICULTURE IN AUTRALASIA.

The British colonies of Australasia are seven in number, New South Wales, South Australia, Western Australia, Victoria, and Queensland, subdivisions of the island or continent of Australia, and Tasmania and New Zealand.

The progress in the past twenty years has been remarkable, and is comparable only with the unequaled advancement of the United States. There is really very much in common between Australasia and this country; the superficial area of each (excluding Alaska) is about the same, their population is English-speaking, and their agricultural products are in the main very similar to ours. The difference in climate is not material. Most of our products, except cotton and tobacco, are well adapted to their soil and seasons. Australasian wheat now meets us in the world's markets; Australasian meat competes with American in supplying the old world's workers with cheap food, and to-day Australasian wool competes with ours in our own home markets. Rapid settlement, improved agricultural methods, and increased rail and water transportation facilities are bringing the antipodes more and more into the competition which now so sorely presses agriculturists of the older countries throughout the world.

The following statement shows the superficial area of each colony, according to the latest official returns, with the population at three periods. In all statements of population it will be understood that the number of aborigines is not included. The native races are everywhere on the decline, and are nowhere material factors in industry or progress.

Colonies.	Area.	Population.		
	Sq. miles.	1861.	1875.	1886.
New South Wales	309,175	202,099	594,257	1,001,966
Victoria	87,884	328,651	791,399	1,003,043
Queensland	668,224	21,231	181,288	342,614
South Australia	903,425	65,048	210,442	312,758
Western Australia	975,920	9,852	26,709	39,584
Tasmania	26,375	49,593	103,663	137,211
New Zealand	104,235	61,035	375,856	589,386
Total	3,075,238	737,509	2,283,614	3,426,562

Taking the official reports for 1881, and eliminating as far as possible everything except gainful callings, the workers of the seven colonies may be approximately divided as follows:

Colonies.	Agriculture.		Manufacturing and mining.		Trade and transportation.		Professional and personal.		Laborers (undefined).		Total No.
	No.	P. ct.	No.	P. ct.	No.	P. ct.	No.	P. ct.	No.	P. ct.	
Victoria	124,202	33	134,667	36	35,184	9	57,153	15	25,736	7	376,942
Queensland	33,267	34	33,117	34	10,742	11	14,978	15	5,533	6	97,637
South Australia	34,820	31	33,533	30	13,288	12	17,501	16	12,151	11	111,293
Western Australia	4,763	39	2,607	22	1,501	12	2,110	18	1,111	9	12,092
New South Wales	76,792	26	68,289	23	28,402	9	63,729	21	64,554	21	301,766
Tasmania	19,408	39	14,484	29	3,884	8	7,597	15	4,484	9	49,857
New Zealand	54,447	29	65,267	35	21,050	11	30,164	16	16,711	9	187,639

It is unfortunate that so large a proportion of workers should be reckoned simply as laborers, it being impossible to determine to which of the four great classes they properly belong. Doubtless a large share are agricultural laborers, but it is equally probable that a larger portion are unskilled day laborers among the urban population. Putting together the five classes for all the colonies, we make up the following statement for Australasia in 1881:

Colonies.	Population.	Agriculture.	Manufacturing and mining.	Trade and transportation.	Professional and personal.	Labor.	Total occupied.	Per cent. of population engaged.
Victoria	880,218	124,202	134,667	35,184	57,153	25,736	376,942	43
Queensland	226,968	33,267	33,117	10,742	14,978	5,533	97,637	43
South Australia	286,324	34,820	33,533	13,288	17,501	12,151	111,293	39
Western Australia	30,013	4,763	2,607	1,501	2,110	1,111	12,092	40
New South Wales	778,690	76,792	68,289	28,402	63,729	64,554	301,766	39
Tasmania	118,923	19,408	14,484	3,884	7,597	4,484	49,857	42
New Zealand	500,910	54,447	65,267	21,050	30,164	16,711	187,639	37
Total	2,822,046	347,699	351,964	114,051	193,232	130,280	1,137,226	40
Per cent. of all occupations	....	31	31	10	17	11	....	......

The manufacturing industries are not so highly developed as the percentages would seem to indicate, that class including those engaged in working the mineral resources of the various colonies, amounting, probably, to half the class.

The governments of the various colonies, recognizing the necessity of a thrifty rural population owning their own homes, have everywhere made provision for the easy transfer of lands from the Crown to actual settlers at nominal prices, providing cheap homes for agricultural colonists, the public domain thus becoming a considerable source of revenue. The laws regulating the disposal of public lands for agricultural purposes differ materially in the different colonies, and in most of them have undergone numerous changes. Besides sales in fee-simple there is in all some plan of deferred payments, by which the settler may take up lands within a certain limit, and pay for them in yearly installments. In addition to the payments,

in all the colonies save Western Australia and Tasmania, it is necessary that improvements to a certain value per acre be placed upon the holding within a specified time, while in Victoria, South and Western Australia, and Tasmania, a portion, ranging from 10 to 25 per cent., must be put in cultivation. If the land is bought under the deferred-payment plan, residence upon it for a certain length of time is necessary, but if the purchase money be paid in full the residence clause is not binding.

The principal features of this deferred-payment system, corrected up to August, 1887, are shown, so far as it is possible to tabulate, in the following statement:

Colony.	Maximum area allowed.	Price per acre.	Time over which purchase may extend.	Minimum time in which fee-simple may be acquired.	Annual payment per acre.	Value of necessary improvements per acre.	Time allowed for making improvements.	Acres in every 100 to be cultivated.	Period of residence necessary.
	Acres.	*£ s. d.*	*Years.*	*Years.*	*£ s. d.*	*£ s. d.*	*Years.*		*Yrs.*
Victoria	320	1 0 0	20	6	1 0	20 0	6	10	5
New South Wales	640 and 2,560	1 0 0	33	5	1 0	(*)	2	......	5
Queensland:									
Homesteads	160	2 6	5	5	6	(†)	5	......	5
Other selections	320 to 1,280	‡1 0 0	....	10	....	(§)	5	......	......
South Australia	1,000	1 0 0	20	10	1 0	10 0	4	20	20
Western Australia	1,000	10 0	20	5	6	(‖)	20	......	5
Tasmania	320	1 0 0	14	(¶)	2 0	....	....	......	14
New Zealand	320	1 0 0 to 2 0 0	10	6	2 0 to 4 0	20 0	6	20	6

* Fencing only.
† 7*s.* 6*d.* to 10*s.*
‡ Upwards.
§ Fencing or 7*s.* 6*d.* to 10*s.*
‖ 10*s.* and fencing.
¶ Any time.

In New South Wales the price per acre does not include interest, for which 4 per cent. per annum is charged. The area which may be taken up varies in different districts. The first payment is 2*s.* per acre, in advance. In South Australia 10 per cent. of the purchase money is paid in advance, 10 more at the fourth year, and 5 at the first of each following year. In Tasmania one-third is added to the price as interest for the period of fourteen years. In all the colonies, when purchase payment is completed the residence clause is no longer binding.

Only one colony has a homestead system approaching, even, the munificent plan which our Government has followed in giving homes to the homeless. In New Zealand 30,000 acres per annum can be disposed of without payment. With a residence of five years and a cultivation of one-third of the area, the selector can claim his Crown grant; no family, however, to hold more than 200 acres.

Under the various systems of alienation a large area of the available public lands of the colonies has passed into the hands of settlers, either for agricultural or pastoral purposes. Up to the close of 1886 the total land alienated and in process of alienation is thus shown:

Colony.	Fee-simple.		In process of alienation by deferred payment.	Total alienated or in process of alienation.	Remaining in Crown.
	Sold.	Granted.			
	Acres.	*Acres.*	*Acres.*	*Acres.*	*Acres.*
Victoria	14,766,771	13,426	7,709,186	22,489,383	33,756,377
New South Wales	22,016,501	3,104,773	16,164,190	41,285,464	156,586,536
Queensland	8,389,942	65,091	2,540,341	10,995,374	416,667,986
South Australia	7,297,638	370,000	3,611,306	11,278,944	566,913,056
Western Australia	1,813,265	....	342,630	2,155,895	622,432,905
Total	54,284,117	3,553,290	30,367,653	88,205,060	1,796,356,860
Tasmania	....	....	....	4,513,454	12,366,546
New Zealand	12,008,157	5,706,726	516,002	19,130,885	47,579,435
Grand total	....	....	....	111,849,399	1,856,302,841

Reaching through more than thirty degrees of latitude, with a wide range of altitudes, all climates are found. The soil is generally very fertile, and the products range from the cereals of the temperate zone to the fruits of the tropics. The principal crops are wheat for exportation, and oats, maize, and potatoes for home demand. The wheat product increased steadily until the last few years, when the competition now so keenly felt throughout the world had its effect upon Australasian growers, checking the steady expansion of acreage. Wheat growers here are at the disadvantage of long distance from markets. The colonies from which the principal supply comes are South Australia, Victoria, and New Zealand, where the rate of yield is about the same as in this country, the others in the aggregate having a deficiency rather than a surplus.

In calculating upon the possible extension of the contribution of wheat from Australasia this fact must be remembered. The population in the colonies which do not grow their own supply is steadily and rapidly increasing, and must be fed by the surplus from the other three. Unlike the natives of India, who subsist upon the cheaper grains, and can thereby largely expand their exports under a strong demand, the people of these colonies are large wheat-eaters, the consumption per capita being possibly greater than in any other country except France, and it is this profitable home demand from a well-fed people that will always be first supplied. The acreage and product, with the net exportation or importation in flour and grain of each colony except Western Australia, in 1883, when the crop was the largest ever grown, are thus shown:

Colonies.	Acres.	Bushels.	Net exportation.	Net importation.
			Bushels.	*Bushels.*
New South Wales	289,757	4,345,437	....	656,335
Victoria	1,104,392	15,570,245	2,288,152	....
Queensland	9,879	42,842	....	1,274,230
South Australia	1,846,151	14,649,230	3,970,535	....
Western Australia	28,768	373,984	....	....
Tasmania	41,301	732,718	15,433	....
New Zealand	377,706	9,827,136	5,139,000	....
Total	3,697,954	45,541,592	11,413,120	1,930,565

This shows a surplus of about 9,000,000 bushels, after supplying home requirements, in the year when the largest crop ever grown was produced and handled. Since that time the proportion of the product available for exportation in the surplus colonies has declined,

while the demand from the importing colonies has measurably increased, and Tasmania, instead of now having a small quantity for export, imports nearly a quarter of a million bushels.

The pastoral interests of the colonies far exceed in value the agricultural, having the advantage of an earlier development and generally more suitable conditions. The increase in the flocks and herds since 1860 has been remarkable and uniform. Wool is, of course, the staple product and constitutes the leading article of export, while during the last few years the shipment of fresh meats has assumed considerable importance, and gives promise of great development in the future.

The numbers of the various classes of stock at different periods since 1870 to 1884, as officially estimated, are thus shown:

Year.	Horses.	Cattle.	Sheep.	Swine.
1870	797,800	4,712,918	51,294,241	694,848
1874	877,277	6,262,919	61,527,122	669,114
1880	1,230,138	8,225,779	75,158,683	1,019,744
1884*	1,304,235	8,464,370	75,626,404	1,108,940

* New Zealand for 1885, except in sheep.

No agricultural statistics for South Australia having been collected since 1884, totals for a later year can not be given.

The production of wool is already affected by the damage done to pasturage by rabbits, and in some of the colonies shows a marked decline. The quantity exported from all the colonies to foreign countries in excess of the imports from such countries is thus shown for a series of years:

Year.	Pounds.	Year.	Pounds.
1872	181,459,780	1879	297,939 084
1873	209,739,473	1880	345,010,338
1874	231,779,119	1881	325,209,385
1875	232,932,196	1882	341,015,397
1876	279,520,873	1883	401,774,926
1877	290,455,316	1884	415,518,258
1878	301,518,670	1885	404,088,149

The quantity and value of the clip of 1886 and the wool trade of that year in each colony are compared by the government statistician of Victoria, in his report for 1886–'87, in the following statement:

Colonies.	Wool production, 1886.				Proportion of exports of wool to total general exports.	Average export price per pound.
	Quantity.		Value.			
	Total.	Average to each sheep.	Total.	Average per head of population.		
	Pounds.	*Pounds.*		£ s. d.	*Per cent.*	*d.*
Victoria	50,439,634	4.71	£2,778,100	2 16 3	42.39	11
New South Wales	171,228,430	4.37	6,947,526	7 1 10	46.30	9¼
Queensland	28,700,546	2.96	1,413,908	4 5 1	28.66	11¼
South Australia	40,991,388	6.12	1,227,007	3 18 5	43.56	8
Western Australia	6,139,917	3.39	332,519	8 18 10	52.75	13
Total	297,499,915	4.37	12,699,120	4 15 10	42.52	10
Tasmania	8,300,180	5.16	319,227	2 7 1	23.35	9¼
New Zealand	92,741,733	5.56	3,200,499	5 10 0	46.05	8
Grand total	398,541,828	4.62	16,218,846	4 16 4	42.47	9¼

The relations of total annual rain-fall to wheat yield per acre are thus shown for the colony of New South Wales:

District.	1882.		1883.		1884.		1885.		1886.		1887.	
	Per acre.	Rain-fall.	Per acre.	Rain-fall.	Per acre.	Rain-fall.	Per acre.	Rain-fall.	Per acre.	Rain-fall.	Per acre.	Rain-fall.
	Bush.	*In.*	*Bush.*	*In.*	*Bush.*	*In.*	*Bush.*	*In.*	*Bush.*	*In.*	*Bush.*	*In.*
Yass	15.2	20.4	17.5	27.8	14.2	20.2	17.0	21.1	11.1	24.3	17.7	27.5
Wellington	13.5	13.3	16.2	21.1	14.1	16.0	17.2	20.3	6.4	20.9	16.2	30.9
Murray River	10.8	18.7	12.3	18.7	13.6	19.1	9.6	15.9	12.1	20.5	14.4	21.7
Orange	17.3	18.4	17.9	21.9	16.7	19.2	15.7	15.0	9.9	17.7	18.3	33.3
Gundagai	18.2	20.3	18.2	22.8	15.8	16.7	18.4	17.6	11.4	22.5	20.2	26.3
Murrumbidgee	14.1	15.6	14.5	17.9	14.4	15.5	14.4	12.0	8.0	16.4	19.9	16.3
Tamworth	17.3	19.3	16.6	26.3	16.0	25.3	16.3	19.7	10.1	21.7	14.7	29.8
Young	17.1	20.4	16.7	27.8	13.4	20.2	17.5	21.1	9.9	24.3	19.2	29.9
Bathurst	14.5	21.2	15.3	21.6	11.9	21.8	14.8	19.5	8.2	20.8	16.4	30.7
Mudgee	14.2	18.2	21.9	21.5	14.1	19.8	18.1	19.8	6.3	24.5	19.0	31.1

In Victoria experiments with irrigation have proved successful as far as tried. In 1884 there were 6,935 acres irrigated; in 1885, 7,046; in 1886, 13,749; in 1887, 21,342. The following table gives the yield per acre upon irrigated and unirrigated land in the latter year:

Crop.	Irrigated.	Unirrigated.	Excess on irrigated land.
Wheat ... bushels	14.92	10.27	4.65
Oats ... do	17.41	14.69	2.72
Potatoes ... tons	4.85	3.62	1.23
Hay ... do	1.27	.62	.65
Grapes ... cwt	25.98	19.10	6.88

DISTRIBUTION OF LAND IN FRANCE.

The French ministry of agriculture made a general agricultural inquiry or census in 1840, 1852, 1862, and again in 1882, that naturally coming in 1872 having been omitted in consequence of the war with Prussia and its demoralizing results. The following table shows the distribution of lands in 1882:

Description.	Average embraced in sub-classes.	Area embraced in principal classes.		Per cent. of total.
	*Hectares.**	*Hectares.*	*Acres.*	
State property:				
Woods and forests	998,854			
Various domains	12,301			
Total state property		1,011,155	2,498,564	1.91
Departmental property		6,513	16,093	0.01
Communal property		4,621,450	11,419,603	8.74
Property of public and other institutions:				
Hospitals	190,122			
Churches, seminaries, and convents	48,271			
Benevolent and charitable institutions	38,022			
Religious congregations	20,423			
Railroads† and various anonymous societies	84,760			
Total property of institutions		381,598	942,920	0.72
Individual possessions		45,025,598	111,258,253	85.19
Total defined property		51,046,314	126,135,442	96.57
Undefined		1,810,885	4,474,697	3.43
Total area of France		52,857,199	130,610,130	100.00

* A hectare is 2.471 acres.
† Of land occupied by railroads only what actually belongs to them is here included.

It appears from the above table that over 85 per cent. of the entire area of France is the property of private individuals. Of the total area there is 95.7 per cent. of agricultural territory, 50,560,716 hectares, or 124,935,529 acres.

The taxable area is 94.7 per cent., 50,035,159 hectares, or 123,636,878 acres.

Deducting from the total agricultural area (50,560,716 hectares) the area embraced in the woods and forests of the state (998,854 hectares), there remains a taxable agricultural area of 49,561,862 hectares (122,467,361 acres).

NUMBER AND SIZE OF FARMS.

Our census designates all places cultivated as "farms," which the English report as "holdings," and the French as "exploitations." It is a portion of land, large or small, farm or garden, orchard or vineyard, under a single management. The three usual divisions relating to size—small, medium, and large culture—were increased in 1882 by another—minute culture. In comparing with our own divisions, it should be understood that our "farms" have a minimum limit of 3 acres, or less than 3 acres if the products reach $500 in value. The following table gives the number of separate places enumerated, according to grade of culture and the proportionate area occupied by each grade:

Classes of farms and designations of cultures.	Number of farms.	Total areas comprised therein.	Average area of one farm.	Proportional distribution— Of the number of farms.	Of the areas comprised therein.
		Hectares.	*Hectares.*	*Per cent.*	*Per cent.*
Minute culture, under 1 hectare	2,167,667	1,083,833	0.50	38.2	2.2
Over 1 hectare:					
Small culture—					
1 to 5 hectares	1,865,878	5,597,634	3.00	32.9	11.3
5 to 10 hectares	769,152	5,768,640	7.50	13.6	11.6
1 to 10 hectares	2,635,030	11,366,274	4.31	46.5	22.9
Medium culture:					
10 to 20 hectares	431,353	6,470,295	15.00	7.6	13.1
20 to 30 hectares	198,041	4,951,025	25.00	3.5	9.9
30 to 40 hectares	97,828	3,424,330	35.00	1.7	6.9
10 to 40 hectares	727,222	14,845,650	20.41	12.8	29.9
Large culture, over 40 hectares	142,088	22,266,104	156.71	2.5	45.0
Totals and average for all farms over 1 hectare	3,504,340	48,478,028	13.83	61.8	97.8
Grand total and general average for all farms	5,672,007	49,561,861	8.74	100.0	100.0

From this table it will be seen that the two smaller classes comprise nearly 85 per cent. of the whole number of farms or holdings, while less than 15 per cent. in the whole of France average more than 25 acres; that the average size of French farms, exclusive of those of less than 1 hectare, which is below our limit, is 33.17 acres, about one-fourth the average size of American farms. The follow-

ing statement shows the proportion of the whole number of holdings and of the total area comprised in each class:

Classes.	Proportion of total.	
	Number of exploitations.	Area in exploitations.
	Per cent.	*Per cent.*
Minute culture	38.2	2.2
Small culture	46.5	22.9
Medium culture	12.8	29.9
Large culture	2.5	45.0
Total	100.0	100.0

The large holdings, while comprising less than 3 per cent. of the whole number, occupy nearly one-half of the whole area. Further subdivision of this class is made, and the very small number of really large farms in France is shown:

Classes of exploitations.	Number of exploitations.	Per cent. of total number.
From 40 to 50 hectares	56,419	39.71
From 50 to 100 hectares	56,866	40.02
From 100 to 200 hectares	20,644	14.53
From 200 to 300 hectares	5,585	3.93
From 300 to 400 hectares	1,653	1.16
From 400 to 500 hectares	704	0.50
Over 500	217	0.15
Total	142,088	100.00

The holdings of less than 10 hectares comprise nearly 85 per cent. of the whole number, although scarcely one-fourth of the total area. Including the places averaging 10 to 20 hectares, the holdings not exceeding 20 hectares include more than 92 per cent. of all and 38.2 per cent. of the whole area. The occupants are almost entirely peasants, the industrious and economical class of sturdy citizens on whom the power of the state chiefly rests. It is, therefore, not accurate to assume that the principal part of the rural territory of France is held in very small farms. Nearly 30 per cent. is in medium holdings of 10 to 40 hectares (24.71 to 98.84 acres) and 45 per cent. in those above 40 hectares. Nor are there many very large farms, there being only 217 exceeding 500 hectares.

In the distribution of these categories of agricultural holdings those of less than 1 hectare are found to be the most numerous near the great centers of population, where gardening is largely developed, and in departments having a rich soil suitable to the cultivation of industrial plants or adapted to vineyard culture.

WHEAT CROP OF INDIA.

The harvest of 1887–'88, as estimated by the revenue and agricultural department of India, aggregates 266,882,112 bushels of 60 pounds each, an average crop, as the "supposed normal outturn" is 264,744,965 bushels. The area is placed at 26,854,882 acres, 3 or 4 per cent. less than the normal area of 27,825,313. The former average area for many years past has been assumed to be 26,000,000 acres in round numbers. The rule has recently been adopted to consider the normal area the "average of the areas of the preceding five years."

The small increase of five years ago has not been sustained, nor has the average production in wheat been enlarged, or the surplus for exportation increased. The prophecies of rapid extension of wheat-growing, made so strenuously by commercial authorities, have not been verified. On the contrary, the views presented by the Statistician have been supported by the facts. The official statement of area and product is as follows:

Wheat crop of 1887–'88 compared with normal crop.

Provinces, etc.	Area.		Outturn.			
	1888, as ascertained up to end of April.	Supposed normal.	Estimated for 1888.		Supposed normal.	
Provinces in which statistics are based on annual survey.	*Acres.*	*Acres.*	*Tons.*	*Bushels.*	*Tons.*	*Bushels.*
Punjab	6,179,800	6,765,000	1,668,506	62,290,890	2,014,671	75,214,384
NW. Provinces and Oudh	*4,952,354	*5,081,500	1,907,000	71,194,667	1,893,150	70,677,600
Central Provinces	4,601,683	3,967,000	1,138,800	42,515,200	845,870	31,579,147
Bombay (including Baroda)	3,010,954	2,871,000	862,475	32,199,067	733,961	27,401,211
Berar	1,052,918	855,000	154,727	5,776,475	128,230	4,787,253
Total	19,797,709	19,539,500	5,731,508	213,976,299	5,615,882	209,659,595
Provinces and native states in which statistics are based on rough estimates.						
Bengal (Behar)	1,085,212	1,267,516	306,000	11,424,000	357,613	13,350,885
Rajputana	1,514,505	1,984,554	365,799	13,656,496	417,208	15,575,765
Central India	2,884,765	3,500,000	508,408	18,980,565	500,000	18,666,667
Hyderabad	1,067,022	1,016,743	102,828	3,838,912	65,328	2,438,912
Mysore	5,669	17,000	752	28,075	2,019	75,376
Kashmir	500,000	500,000	133,333	4,977,765	133,333	4,977,765
Total	7,057,173	8,285,813	1,417,120	52,905,813	1,475,501	55,085,370
Grand total	26,854,882	27,825,313	7,148,628	266,882,112	7,091,383	264,744,965

* The areas for Northwest Provinces and Oudh are exclusive of land on which wheat and some other grain were grown together.

HOP PRODUCTION IN EUROPE.

The area and product of hops, as deduced from the records of production of the principal hop-growing countries of Europe for several years past, are thus presented:

GREAT BRITAIN.

Years.	Acres.	Product.		Yield per acre.
		Cwts.	*Pounds.*	*Pounds.*
1885	71,327	509,170	57,027,040	800
1886	70,127	776,144	86,928,128	1,240
1887	63,709	457,515	51,241,680	804
1888	58,494	....	....	....

FRANCE.

Years.	Area.		Product.		Rate of yield.	
					Per hectare.	Per acre.
	Hectares.	*Acres.*	*Quintals.*	*Pounds.*	*Quintals.*	*Pounds.*
1883	3,469	8,572	41,250	9,093,975	11.89	1,061
1884	3,326	8,219	45,533	10,038,205	13.69	1,221
1885	3,863	9,545	49,404	10,891,606	12.79	1,141
1886	3,456	8,540	41,149	9,071,709	11.91	1,062

NETHERLANDS.

1883	187	462	2,430	535,718	12.99	1,160
1884	206	509	3,730	822,316	18.11	1,616
1885	211	521	1,830	403,442	8.67	774
1886	218	539	3,220	709,881	14.77	1,317

GERMANY.

1883	45,937.1	113,511	221,802	48,898,469	4.83	431
1884	46,689.5	115,370	288,700	63,646,802	6.18	552
1885	47,390.5	117,102	332,011	73,195,145	7.01	625
1886	47,370.5	117,053	302,025	66,584,432	6.38	569
1887	46,952.4	116,019	243,934	53,777,690	5.20	464

AUSTRIA.

1883	....	....	39,179	8,637,402	....	....
1884	12,525	30,949	40,064	8,832,509	3.20	285
1885	12,775	31,567	58,044	12,796,380	4.54	405
1886	14,560	35,978	49,225	10,852,144	3.38	302

COMPARATIVE RATES OF YIELD.

For convenient comparison of the rates of yield in the several countries, they are presented in pounds per acre in parallel columns below:

Years.	United Kingdom.	France.	Netherlands.	Germany.	Austria.
1878	....	1,049	804	624	319
1879	....	906	897	375	452
1880	....	990	939	536	477
1881	....	934	978	532	383
1882	....	835	845	404	361
1883	....	1,061	1,160	431	....
1884	....	1,221	1,616	552	285
1885	800	1,141	774	625	405
1886	1,240	1,062	1,317	569	302
1887	804	....	....	464	....

DIVISION WORK AND METHODS.

The work of this Division includes every department of agricultural statistics, in this country especially, and throughout the world so far as relates to foreign products that compete with those of the United States. It involves the record, tabulation, and co-ordination of such statistics of production, distribution, and consumption, the authorized data of governments, institutes, societies, boards of trade, and of individual experts. It requires the collation and record of prices, a series of invaluable statistics illustrating the action of the law of supply and demand, trade regulations and restrictions, monetary distribution, and even the changes caused by the arbitrary edicts of fashion.

The publications of this Division consist of an annual report which is published in the annual volume issued by order of Congress; a monthly series of reports of the Statistician; occasional special reports, involving more thorough statistical investigation of topics of present public interest; and maps and charts illustrating the statistics of agriculture. Of the monthly, an edition of about 20,000 is issued for the use of county reporters and for editors and writers, as it is practicable to furnish the information only through the medium of the press, and not to the millions of individuals interested. The main purpose of the crop reports is to give accurate information of crop areas, conditions, and prospects, for the information of producers and consumers, and for their protection against combination and extortion in the handling of the products of agriculture. For this purpose the theory is accepted that the unadorned truth, without exaggeration or underestimate, is the best for growers and buyers.

The crop-reporting section of this Division is important, and naturally elicits a popular interest, but it does not pretend to occupy a place in the domain of exact statistics. Its uses are mainly temporary. The organization of this work was referred to on the first page of this report. The methods may not be so well known, and may properly be indicated in connection with the reference to the general scope of the work of the Division in the preceding paragraph.

County correspondents make monthly returns on the first day of each month by filling blank forms relating to special topics. As the main inquiries occur annually in the same month, the correspondent knows precisely what is expected and prepares for it. Occasionally a new subject of inquiry gives variety to the work. The regular investigations relate to increase or decrease of farm animals, commercial distribution of farm products, condition of farm stock at the close of the winter, losses of farm animals during the year, condition of winter grain in spring, the progress of spring planting, the relative area of the principal crops, condition of growing crops up to the time of ripening, yield per acre, and the product of the year. These comparisons are made for each county, which has a known status in production.. Were they for unknown areas, some for a large district, others for a small one, or for a single farm, the result would be uncertain and inconsequential.

The effect of differences in crop areas covered by reports, upon the averages of a State, is so great as to render valueless a "straight average," or the average of the amateur. This is found by adding the percentage column and dividing by the number of returns. The true average is found by giving to each return its proper weight or

relative standing in production of the crop under consideration. The following statement, supposed to be the return of condition of corn in five Illinois counties, will clearly illustrate the two averages and their differences:

County.	Percentage of condition.	Normal crop.	Crop modified by condition.
		Bushels.	
McLean	98	11,976,581	11,737,049
Alexander	65	454,705	305,558
La Salle	100	11,148,779	11,148,779
Hardin	70	306,960	214,872
Massac	67	450,010	301,507
Total	400	24,337,035	23,707,765
Average of condition	80	....	97.4

This extended or true average is thus worked out for each question and each State for every county reported. The apparent indication of the average by number of counties in this example, is for four-fifths of a full crop; the real significance of the returns is a depreciation of only 2.6 per cent. instead of 20 per cent. The error amounts to over one-sixth of the crop, and it is in the compilation and not in the county estimates. This shows the utter irrelevancy and worthlessness of an average based on the number of returns, with no reference to the breadth of crop covered by each.

The tabulation, including this arithmetical consolidation to obtain a true average of the local estimates as returned, is ready for the statistician on the seventh or eighth day of each month, who scrutinizes the original returns, makes allowances for obvious misinterpretation of inquiries and manifest vagaries in judgment, harmonizes discrepancies between these results and parallel results obtained by State agents in a similar way, and thus perfects the State averages. The general average of the crop, for the country as a whole, is made by a similar application of State averages to the aggregate products of each.

The section of freight rates collects every month the freight rates charged by the transportation companies of the United States on the first day of the month and prepares the returns for publication in the monthly reports. This section also supervises the work of the State statistical agents, which is similar, in a limited area, to the crop-reporting work of the Statistician, and comprises also local special investigation.

The consuls of the United States, with the aid of European statisticians and experts in agricultural and commercial information, also collect for the use of this Division statistics which relate primarily to those products in which the United States have a competitive interest. Mr. E. J. Moffat, deputy consul-general at London, has had the direction of this branch of the service since its organization, and is worthy of special commendation for his efficiency and promptness.

The Division is also about to make a statistical survey of the States aud Territories of the vast Rocky Mountain region, the agricultural capabilities of which are as yet comparatively unknown; and also, from time to time, a similar survey of the resources and products of the older States.

An important feature in the current work of this Division is the preparation of a series of charts and maps to show the geographical distribution and limitation of important crops. During the past year a series of large maps and diagrams was prepared for the Cincinnati Centennial Exposition and exhibited during its continuance, and another has been sent to the Paris Exposition, to be exhibited during the summer of 1889.

In this series four large maps of the United States are presented, illustrating the progress of twenty-eight years in the growing of cereals, cotton, and tobacco, and showing the distribution of each product, by States, at three different dates.

The diagrams, sixteen in number, show the local variation in rate of production of some of the principal crops, and the annual variation of the aggregate product, the relation of price to production, and the proportion of products exported. It also shows the distribution and increase of farm animals, the annual exportation of beef products, and the aggregate value by decades of all exports of beef and beeves, and the course of exportation of swine products. Among other points of illustration are the rates of wages of farm labor, by groups of States, the values at different dates of principal products, and a classification of agricultural and non-agricultural products in the foreign trade of the country, including both exports and imports. The progress of railroad building is also shown, from 1850 to the present time.

The following are the titles of the graphic illustrations which exhibit the resources and production of American agriculture at the coming world's exposition at Paris:

No. 1. Wheat Distribution in the United States. Crops of 1859, 1879, and 1887.
No. 2. Corn Distribution in the United States. Crops of 1859, 1879, and 1887.
No. 3. Oats Distribution in the United States. Crops of 1859, 1879, and 1887.
No. 4. Cotton and Tobacco Distribution in the United States. Crops of 1859, 1879, and 1886.
No. 5. Product and Export of Corn.
No. 6. Average Yield and Price of Corn, 1871 to 1877.
No. 7. Acreage and Product of Wheat.
No. 8. Product and Export of Wheat.
No. 9. Progress of Cereal Production.
No. 10. Produce Per Capita of Cereals in Europe and the United States.
No. 11. Increase of Farm Animals.
No. 12. Export of Hog Products.
No. 13. Exports of Beef.
No. 14. Product and Export of Cotton, 1841 to 1887.
No. 15. Increase of Values of Farm Products.
No. 16. Value of products of American Agriculture. Proportion Exported 1886–'87.
No. 17. Average Wages of Farm Labor.
No. 18. Foreign Trade of the United States 1887–'88.
No. 19. Dietaries of Different Peoples.
No. 20. Increase of Railroad Mileage in the United States.

The clerical force actually employed in the Division work averages fifty-five persons. The demands upon the service are constantly increasing, as the interests of agriculture are enlarged in the United States, and as the appreciation of the practical value of statistics, in legislation, in business, in rural and social economy, becomes more general and profound.

J. R. DODGE,
Statistician.

Hon. NORMAN J. COLMAN,
Commissioner.

REPORT OF THE ORNITHOLOGIST AND MAMMALOGIST.

WASHINGTON, D. C., *January*, 1889.

SIR: I have the honor to submit herewith my third annual report upon the operations of the Division of Economic Ornithology and Mammalogy, covering the year 1888. It consists of five parts, as follows: (1) Scope of the work; (2) methods of inquiry; (3) statement of work done during the year; (4) the geographical distribution of species; and (5) special reports embodying results of investigations.

Respectfully,

C. HART MERRIAM,
Chief of Division of Ornithology and Mammalogy.

Hon. NORMAN J. COLMAN,
Commissioner of Agriculture.

In my last report two bulletins were mentioned as ready for the printer. One of these, on the English Sparrow in America, is still in the hands of the Public Printer. The other, on Bird Migration in the Mississippi Valley, was issued in November, 1888. It is a compact octavo volume of 313 pages, accompanied by an admirable colored altitude map of the Mississippi Valley, showing in different tints the contours of 100, 500, 1,000, and 2,000 feet, and also the position of the observation stations. The publication of this work is an event of much importance both to the Department of Agriculture and to the science of ornithology. Its distribution to the regular observers of the Division has resulted in the receipt of letters from hundreds of persons desirous of securing it, many of whom have volunteered their services as observers; and it has given a great stimulus to the study of ornithology in the region of which it treats—a region covering more than one-third the total area of the United States, and including considerably more than half the species and subspecies of birds known to inhabit North America. It affords a more substantial foundation for the detailed study of the distribution and migration of birds than exists in any other portion of the world.

SCOPE OF THE WORK.

The scope of the work of this Division, as defined by act of Congress, is, "the promotion of economic ornithology and mammalogy, an investigation of the food habits, distribution, and migrations of North American birds and mammals, in relation to agriculture, horticulture, and forestry." The function of the Division, then, consists

in the collection of facts relating to the above subjects, and in the arrangement and publication of these facts in the form of special reports and bulletins. The field thus outlined is so large, and the amount of money appropriated for the work so small, that it is impossible to cover more than a very limited portion of the ground; hence of necessity the investigations thus far made have been along special lines. At the same time, since it costs no more to ask ten questions than it does to ask one, it has been the policy of the Division in preparing its circulars and schedules to request more information than can be put to immediate use, hoping that at some future time it may be possible to elaborate and publish the whole. The result of this course is the receipt of an immense mass of material of great value, which the limited force of the Division is wholly unable to handle.

METHODS OF INQUIRY.

The principal ways of gathering information are, (*a*) by personal observation on the part of the staff of the Division and its special field agents; (*b*) by the co-operation and assistance of farmers and others in extending these observations over the entire country; (*c*) by the collation of what has been already published on the subject; and (*d*) by examination of stomach contents in the laboratory. With these objects in view general circulars and schedules on the migration and geographical distribution of birds have been sent out twice each year, and special circulars, asking for detailed information on particular subjects, have been issued from time to time.

STATEMENT OF WORK DONE IN 1888.

The work of the Division during the year 1888 has been confined to the collection and elaboration of material relating to the general subjects already mentioned.

My last report contained tabulated results of the critical examination of more than a thousand stomachs of hawks and owls, prepared by Dr. A. K. Fisher, assistant ornithologist. The work in this direction has been continued during the past year, and the final results, together with copious notes on the distribution and food habits of the species concerned, will appear in a special illustrated bulletin already in an advanced stage of preparation.

Another assistant, Prof. Walter B. Barrows, has spent much time in the examination of the stomachs of crows, the results of which are incorporated in the present report.

In undertaking to identify the stomach contents of fruit-eating and seed-eating birds, it became evident at once that no substantial progress could be made without a reference collection of seeds, berries, and the pits of fruits. Such a carpological collection does not exist either in the Department of Agriculture or the United States National Museum. Therefore it has been necessary for members of the Division to collect this indispensable material in order to carry on the work of identifying the stomach contents of crows, blackbirds, and many other species.

Considerable progress has been made in arranging for publication the large amount of information in hand relating to the depredations of Blackbirds, but this work, as well as that relating to the Rice-bird or Bobolink, is held back temporarily for lack of sufficient competent field observation and experiment to complete the investigations and determine the economic status of the species.

Perhaps the most important feature of the work of the year has been the collection and partial arrangement of material for one or more bulletins on the Pocket Gophers and Ground Squirrels of the United States, an undertaking of surpassing importance to the agriculturists not only of the Mississippi Valley but of nearly the whole of the western two-thirds of the continent. The magnitude of the losses occasioned by these animals, and the imperative demand for remedies, are almost unknown in the Eastern States. During the past summer an energetic field agent has devoted much time to this work in Nebraska, Dakota, Wyoming, and Utah, and the chief of this Division visited parts of Montana, Washington Territory, Oregon, and California in order to study personally the different phases of the problem there presented, as well as the remedial measures employed by the inhabitants.

The attempt to remedy the Gopher evil by the award of bounties has proved as useless as in the case of the Rabbit plague and Sparrow scourge; and the persistency with which this method is resorted to shows the necessity for a compilation of bounty laws and their results, at least in the United States. Such a compilation was begun two years ago in connection with the Sparrow investigation, and has been continued since, its scope having been enlarged to cover all legislation directly affecting undomesticated birds and mammals. During the year 1888 letters have been written to all the county treasurers of Minnesota, Dakota, and Iowa, two hundred and eighty in number, asking if bounties were paid on Gophers, and, if so, requesting specific information as to the statute or ordinance under which said bounties were offered, the dates between which the law was held operative, and the amounts disbursed on account of each species. A synopsis of the information received in reply to these letters will appear in the Gopher bulletin.

A not unimportant incidental feature of the routine work of the Division consists in the identification of specimens of birds and mammals sent to the Department for this purpose. Among those received during the year 1888, in addition to those sent by private individuals scattered over the whole country, were small collections from the Geological and Natural History Survey of Canada (including several species new to science), and from the museum of Lavalle University at Quebec. The total number of specimens received for identification in 1888 considerably exceeded a thousand. The number is constantly on the increase, and it is hardly necessary to add that great good is done by thus diffusing among the people an accurate knowledge of the birds and mammals with which they are surrounded.

The routine work of the Division has been reduced to a system designed to expedite the various operations involved, and to facilitate reference to and future collation of the voluminous material collected; but the amount of office work largely increases from year to year, and has already assumed dimensions disproportionate to the working force.

General circulars and schedules relating to the migration and geographical distribution of North American birds are mailed semi-annually to nearly three thousand regular correspondents, and circulars on special subjects are prepared and sent out as occasion demands.

Scores of thousands of small birds are killed each year by striking the light-houses along the coasts and lakes of the United States and

Canada, and the keepers of these lights are requested to transmit to this Division full accounts of the phenomena accompanying such catastrophes, together with specimens (heads and wings) of the birds killed. The material thus contributed is sufficient in itself to occupy an assistant during the entire year, and when to this is added the equally valuable reports of many hundred voluntary inland observers throughout the United States and Canada, it will be seen that little can be accomplished with the present force of the Division, now almost exclusively occupied in the more purely economic phases of the work.

All information received, whether in reply to circulars or contributed independently, is indorsed with the name and address of its contributor, the date, and a brief statement of its contents; it is then filed and indexed for ready reference. Careful separation is made of notes relating to the different subjects under investigation in order to facilitate its ready access and arrangement for bulletins or reports on special species or groups of species. A record index of all matter received is kept on cards printed for that purpose, and arranged alphabetically according to localities. General interest in the practical work of the Division increases, and a very large item of office work is that which relates to the regular correspondence of the day. Upwards of three thousand letters were answered during the year 1888, many of which necessitated considerable research in order to answer the inquiries contained. All communications received are promptly acknowledged, and press copies are taken of all letters written.

CINCINNATI EXPOSITION.

In the summer and fall of 1888 an exposition, entitled the "Centennial Exposition of the Ohio Valley and Central States," was held at Cincinnati, Ohio, opening July 4 and closing November 8. As a part of the exhibit of the Agricultural Department this Division placed on exhibition a collection of the birds of prey of the United States. Through co-operation with the United States National Museum the series of species shown was very complete, nearly every known species of North American Hawk and Owl being represented by at least one specimen. In many cases the young as well as the adults were exhibited, and both sexes where the plumage of the male differs from that of the female. To each specimen was attached a large printed label, giving its common and scientific names, its distribution, and its food. Following is an example of one of these labels:

RED-TAILED HAWK.

Buteo borealis (Gm.).

Habitat.—Eastern North America to and including the Mississippi Valley; north to the Fur Countries; south through eastern Mexico to Guatemala.

Food.—Mice and other small mammals, toads, snakes, frogs, and crawfish, with an occasional chicken or small bird.

Of 311 stomachs examined, 258 contained mice and other mammals; 24, insects; 29, poultry or game birds; 35, other birds; 9, batrachians or reptiles; 4, offal; 3, crawfish; and 29 were empty. Two hundred and ten examined by the Division contained 270 mice.

The following species of birds of prey were exhibited:

Red-tailed Hawk (Buteo borealis).
Western Red-tailed Hawk (Buteo borealis calurus).
Harlan's Hawk (Buteo harlani).
Swainson's Hawk (Buteo swainsoni).
Zone-tailed Hawk (Buteo abbreviatus).
Red-shouldered Hawk (Buteo lineatus).
Red-bellied Hawk (Buteo lineatus elegans).
White-tailed Hawk (Buteo albicaudatus).
Broad-winged Hawk (Buteo latissimus).
Rough-legged Hawk (Archibuteo lagopus).
American Rough-legged Hawk (Archibuteo lagopus sancti-johannis).
Squirrel Hawk (Archibuteo ferrugineus).
Harris's Hawk (Parabuteo unicinctus harrisi).
Mexican Black Hawk (Urubitinga anthracina).
Goshawk (Accipiter atricapillus).
Mexican Goshawk (Asturina plagiata).
Osprey or Fish Hawk (Pandion haliætus).
Audubon's Caracara (Polyborus cheriway).
Golden Eagle (Aquila chrysætos).
Bald Eagle (Haliæetus leucocephalus).
Duck Hawk (Falco peregrinus anatum).
White Gyrfalcon (Falco islandus).
Prairie Falcon (Falco mexicanus).
Sparrow Hawk (Falco sparverius).
Pigeon Hawk (Falco columbarius).
Richardson's Merlin (Falco richardsoni).
Aplomado Falcon (Falco fusco-cœrulescens).
Mississippi Kite (Ictinia mississippiensis).
White-tailed Kite (Elanus leucurus).
Swallow-tailed Kite (Elanoides forficatus).
Everglade Kite (Rostrhamus sociabilis).
Marsh Hawk (Circus hudsonius).
Sharp-shinned Hawk (Accipiter velox).
Cooper's Hawk (Accipiter cooperi).
Great Horned Owl (Bubo virginianus).
Western Horned Owl (Bubo virginianus subarcticus).
Great Grey Owl (Scotiaptex cinereum).
Snowy Owl (Nyctea nyctea).
Barred Owl (Syrnium nebulosum).
Spotted Owl (Syrnium occidentale).
Barn Owl (Strix pratincola).
Hawk Owl (Surnia ulula caparoch).
Richardson's Owl (Nyctala tengmalmi richardsoni).
Saw-whet Owl (Nyctala acadica).
Screech Owl (Megascops asio).
Flammulated Screech Owl (Megascops flammeolus).
Ferruginous Pygmy Owl (Glaucidium phalænoides).
Pigmy Owl (Glaucidium gnoma).
Elf Owl (Micropallas whitneyi).
Burrowing Owl (Speotyto cunicularia hypogæa).
Short-eared Owl (Asio accipitrinus).
Long-eared Owl (Asio wilsonianus).

In addition to the series of birds of prey above enumerated, the Division put on exhibition the following other birds of known economic importance:

Bobolink (Dolichonyx oryzivorus).
Cowbird (Molothrus ater).
Yellow-headed Blackbird (Xanthocephalus xanthocephalus).
Red-winged Blackbird (Agelaius phœniceus).
Rusty Blackbird (Scolecophagus carolinus).
Purple Grackle (Quiscalus quiscula).
Boat-tailed Grackle (Quiscalus major).
Meadow Lark (Sturnella magna).
Bob-white (Colinus virginianus).

A collection of mammals also was exhibited, comprising the following:

Opossum (Didelphis virginianus).
Prairie Dog (Cynomys ludovicianus).
Beechey's Spermophile (Spermophilus grammurus beecheyi).
Richardson's Spermophile (Spermophilus richardsoni).
Striped Spermophile (Spermophilus tridecemlineatus).
Red Squirrel (Sciurus hudsonius).
Muskrat (Fiber zibethicus).
Meadow Mouse (Arvicola riparius).
Rice Field Mouse (Oryzomys palustris).
White-footed Mouse (Hesperomys leucopus).
House Rat (Mus decumanus).
Pocket Gopher (Geomys bursarius).
Gray Pocket Gopher (Thomomys bulbivorous).
Porcupine (Erethizon dorsatus).
Rabbit (Lepus sylvaticus).
Short-tailed Shrew (Blarina brevicauda).
Mole (Scalops aquaticus).
Star-nosed Mole (Condylura cristata).
Skunk (Mephitis mephitica).
Badger (Taxidea americana).
Weasel (Putorius erminea).
Mink (Lutreola vison).
Gray Fox (Urocyon virginianus).
Red Fox (Vulpes fulvus).
Prairie Wolf or Coyote (Canis latrans).
Wildcat (Lynx rufus).

THE GEOGRAPHICAL DISTRIBUTION OF SPECIES.

The subject of the geographical distribution of species is one whose importance from the economic stand-point can hardly be overestimated, and one which ought to receive vastly more attention than can possibly be given it with the present limited means at the disposal of the Division. As the work of the geologist in his search for coal-fields and mineral wealth must be preceded by the work of the topographer, who furnishes him maps on which to indicate the position of his discoveries, so should the work of the economic zoologist be based on a knowledge of the geographic distribution of species. Were this knowledge available, both the agricultural experiment station and the intelligent farmer, wherever located, would derive great benefit therefrom, and millions of dollars now spent in indiscriminate experimentation might be saved.

In order to understand this fully it is necessary to bear in mind certain fundamental facts and laws. It is a matter of common observation that different groups of animals and plants inhabit different regions, even in the same latitude; that some forms are almost cosmopolitan in distribution, while others are restricted to very limited areas; that the ranges of very dissimilar species are often geographically coincident; and that, as a rule, animals inhabiting contiguous areas are more nearly related than animals inhabiting remote areas. The recognition of these facts early led to the attempt to divide the surface of the earth, according to its animal life, into "*faunal*" districts. The term "fauna" is used to designate the sum of the animal life of a region.

As a general rule it may be stated that the causes which govern the distribution of one group of land animals govern also the distribution of other groups of land animals, and of plants as well. It follows that a plant or animal found abundantly inhabiting any part of a particular faunal area will be found in other parts of that area, subject, of course, to local restrictions. The practical application of this knowledge is obvious.

In experimenting with a crop or garden plant of limited natural or artificial* range it would be necessary only to ascertain the extent of the faunal area in which it thrives in order to know just where it might be introduced with every prospect of success, soil and other local modifying influences being suitable. Moreover—and this perhaps is of even greater importance from the economic stand-point—the possession of this knowledge would indicate in advance the limits of the area outside of which the plant would not flourish. Plants are much more susceptible than animals to minor environmental influences, such as slight differences in altitude and soil, daily variations in temperature, humidity, exposure to sunlight, and protection from wind; therefore slight local conditions which would be unnoticed in the case of mammals or birds must be carefully considered in the case of plants.

This is but one of the ways in which a knowledge of the distribution of species would be of advantage to the practical agriculturist. It would help him also in his relations with injurious and beneficial species, as he would know beforehand just what species were to be looked for in his immediate vicinity. Furthermore, in the case of noxious animals or weeds which from time to time suddenly extend

* By artificial range is meant the range resulting from the voluntary acts of man.

their range, it would be possible, if the faunal status of a particular species had been previously ascertained, for farmers living within the particular area or province likely to be invaded to prepare in advance for its coming, or to avoid its inroads altogether by planting crops not affected by it. On the other hand, farmers living outside of the region over which this species would be likely to pass might greatly increase their revenues by giving special attention to the cultivation of the particular crops affected by it. In short, a knowledge of the faunal areas and provinces of the United States, coupled with the results of intelligent experimentation on the part of the various agricultural stations, would enable our farmers to select the crops best adapted to their localities, and would put an end to the present indiscriminate experimentation by which hundreds of thousands if not millions of dollars are needlessly expended each year. Agriculture and biology must be studied from the geographic stand-point before we can hope to avail ourselves of the means within our grasp for the rapid advancement of these sciences. But geography is only a part of the broader science of physiography. Physiography deals with the earth's exterior in relation to the atmosphere; it attempts to correlate the forms of the land—the mountain ranges, table lands, plains, valleys, and water-courses—its geologic structure, soil, elevation above sea level, and slope exposure in relation to sunlight, with the phenomena of climate, including temperature and moisture in their various aspects.

Our aim should be to explain the distribution of animals and plants by means of a knowledge of the conditions which govern this distribution, and to formulate the laws which are operative in bringing about the results we see. In other words, we are to study cause and effect in the relations of physiography to biology. A comparatively meager supply of information is sufficient to indicate in a general way the faunal subdivisions of a region, but for mapping the exact boundaries of such areas a vastly greater and more precise fund of knowledge is necessary. The way in which such maps are prepared is by collecting all available authentic records of localities where the particular species has been found. This is done by compilation of published records, by examination of labels of museum specimens, and by work in the field, the latter being by far the most important. The facts thus brought together are arranged alphabetically, and are tabulated under the head of "Species." The localities are then indicated by colored spots on an outline map, the space surrounded by the spots being washed in with a paler tint of the same color. A separate map is devoted to each species. Faunal maps are made by combining a large number of species maps. In making such combinations it is found as a rule that a considerable percentage of the species maps fall into certain well-defined categories whose color patches are essentially coincident. The composite resulting from the co-ordination of these maps may be held to represent the natural faunal areas of a country. Several such areas may be characterized by the common possession of species not found elsewhere, and may be combined to constitute a faunal province; several provinces a region, and several regions a realm or primary zoo-geographical division of the earth's surface. Having ascertained the actual extent and limitations of the faunal districts, it remains to correlate the facts of distribution with the facts of physiography. Foremost among the influences known to affect the distribution of terrestrial forms of life are the protean elements and manifestations commonly termed climate. To stop at

the word "climate" is a profession of ignorance. We must look to the separate elements that go to make up climate, and must study the physical features which determine the so-called climatic conditions prevalent in any region. Among the most potent of atmospheric influences are temperature, humidity, and wind, each of which must be considered both singly and in combination with one or both of the others.

Finally, the interrelation of plants and animals must not be lost sight of. Here we have to do with the influences of vegetation—of forests, thickets of undergrowth, plains of sage-brush, prairies of waving grass, and the multitude of other forms which plants assume in their efforts to hide the bare surface of the earth—upon the distribution of animal life. Conversely, the effects of animal life in checking or limiting the growth and dispersion of plant life remain to be considered. And this takes us back to the original economic work of the Division.

The great importance of a knowledge of the geographic distribution of species, particularly in view of the large sums recently appropriated for the establishment of agricultural experiment stations in various parts of the country, has led the Division to undertake the preparation of a number of colored maps showing what is now known of the distribution of particular species of mammals and birds. Only a beginning has been made, and further progress must be slow for want of adequate means to carry on the work. Competent field agents must be sent to many parts of the country to collect information before the work can be completed. It is hoped that the means of doing this will be granted the Division.

SPECIAL REPORTS.

The following special reports will be found herein:

(1) Introduced Pheasants. By Dr. C. Hart Merriam, Ornithologist.
(2) The Mink (*Lutreola vison*). By Dr. C. Hart Merriam, Ornithologist.
(3) The Sparrow Hawk. By Dr. A. K. Fisher, Assistant Ornithologist.
(4) The Short-eared Owl. By Dr. A. K. Fisher, Assistant Ornithologist.
(5) The Food of Crows. By W. B. Barrows, Assistant Ornithologist.
(6) The Rose-breasted Grosbeak, an Enemy of the Potato Bug.

INTRODUCED PHEASANTS.

PACIFIC COAST REGION.

Four flourishing colonies of introduced Pheasants now exist in the Pacific Coast region. The most northerly of these is on the south end of Vancouver Island, near Victoria; the second on Protection Island, in Puget Sound; the third at the junction of the Willamette River with the Columbia; and the fourth in the middle portion of the Willamette Valley. The two latter colonies are now separated by so narrow a strip of territory that they will doubtless become united during the next few years. The above facts were ascertained by personal observation in the early autumn of 1888. All of the Pheas-

ants comprising the three colonies last mentioned appear to have been imported from China by Judge O. N. Denny. Concerning the exact dates of the several importations, and the number and kinds of birds imported, it is difficult to obtain positive information, as may be seen from the somewhat conflicting testimony appended to this article. The species positively ascertained to be present in the Oregon colonies are the following: The Golden Pheasant (*Chrysolophus pictus*), Green Pheasant (*Phasianus versicolor*), and Ring Pheasant (*Phasianus torquatus*), of which the latter is by far the most abundant. I am not aware that the so-called English Pheasant (*Phasianus colchicus*) is found in Oregon, though it is the species most frequently introduced in the Eastern United States.

On Protection Island, near Port Townsend, in Puget Sound, there are at present three species of imported Pheasants, namely: The Golden, the Mongolian or Ring-necked, and the Silver. They were sent there by Judge O. N. Denny, from China, along with two other species which soon disappeared and have not been since heard from. One of the latter seems to have been a species of Partridge. I was told that these birds were sent to Protection Island for the purpose of breeding and multiplying in order that they might be exported to stock various parts of the Pacific coast region, particularly in Oregon and California. The owner of the island, a Mr. Powers, was paid at first to take care of the Pheasants, to feed them when necessary, and to keep off shooters. After the first year or two, however, the pay was discontinued and the Pheasants became the property of the owner of the island. I am informed that the island has been sold recently, together with the Pheasants, to some one in California. The Golden Pheasants and Ring-necks have multiplied and are now abundant, but the Silver Pheasants have decreased, and not more than about a dozen are left. They are shy and keep in the woods. The Golden Pheasants are tame, and will even eat from the hand. The Ring-necks are said to be the most numerous of all, and to be as wild as the native Grouse. About half the island is cleared and has grown up to grass, the remaining portion being covered with dense evergreen forests and undergrowth. I am told that the Crows, doubtless *Corvus caurinus*, have learned the nesting habits of the Pheasants and are likely to prove a check to their increase, as they devour the eggs.

Mr. A. H. Morgan, of Portland, Oregon, has given me the following information concerning the importation of Pheasants into Oregon: All the birds imported were sent from China by Judge O. N. Denny, then consul-general to Shanghai, at a total cost of about $300. They were shipped to Mr. Morgan, my informant, who personally looked after and liberated them.

PHEASANTS.—The first importation (1881?) consisted of Mongolian Ring-necks, with the exception of three Sand Grouse or Partridges, which latter were never heard from after their liberation. This batch was shipped on a vessel which went to Puget Sound. The Pheasants were put into chicken crates and sent from Puget Sound to Portland, where Mr. Morgan received them. Most of them died on the way, but twelve males and three females reaching Portland alive. These were taken at once to the farm of George Green, at the mouth of the Willamette River, about 12 miles from Portland, where they were set at liberty. Though wild they returned to the barn-yard to feed with the chickens. This was in spring. During the summer two of the three hens were observed with

broods, and it was thought that the third hen was successful also in rearing young. At all events they began to spread in the fall of the same year, and were found on Sophia Island as well as at several places on the main-land before winter. They wintered well, and have been increasing ever since. They are now common. Soon after their importation the legislature passed a special act for their protection.

The second importation (1882?) consisted wholly of Mongolian Ring-necks. Thirty-five or thirty-six birds, about half of each sex, were sent direct from China to Portland, where they arrived in fair condition. They were taken to Washington Butte, about 12 miles east of Albany, in the Willamette Valley, and there liberated. Within two months a pair was observed on a farm 50 miles from the place where they were set at liberty. They crossed the river into Polk County the same year, and are now abundant in Polk, Marion, and Linn Counties. The two original colonies have never met, there being an area across the Lower Willamette where Pheasants have not yet appeared. Some complaints of their depredations in grain fields have been made by farmers.

SAND GROUSE.—In or about 1881 nine Sand Grouse were liberated on the Clatsop Plains. They promptly disappeared and have not been heard from since.

The *American Field* for January, 1885 (p. 57), contains the following notice:

Arrival of Chinese Game Birds.—Judge O. N. Denny, who arrived here from China by the last steamer, says the *Portland Oregonian*, brought with him thirty baskets and seven crates of Chinese game birds. They comprise specimens of six varieties of the pheasant family, and arrived in splendid order, only four of about ninety birds shipped having died; * * * of the number thirty-one are Golden Pheasants. * * * The remainder are Silver, Copper, Green, Trogapan, and Ring-necked Pheasants, there being only a few of the latter, of which Judge Denny made several shipments while in China, which are now doing well and increasing rapidly in various sections of the State.

Mr. Asher Tyler, of Forest Grove, Oregon, has kindly written the following in reply to my inquiries on the subject:

From the time the Pheasants mentioned in your letter were imported by Judge O. N. Denny I have watched them closely and have learned their habits thoroughly.

(1) The *Ring-necks* were let loose in 1882. Fifteen females and ten males were placed on Judge Denny's farm, 95 miles south of Forest Grove. Two years ago two or three were seen in our neighborhood. Now (January 21, 1889) there are about two hundred of them in our vicinity, having spread very rapidly and increased wonderfully. The females produce from fifteen to eighteen eggs of good size at each litter, and hatch them all. Some of them lay two litters a year or season, and raise all their young. The old ones have lots of nerve; will fight a hawk, or anything that comes near them. The cocks will go in a barn-yard and whip the best barn-yard fowls we have, and run things according to their own notion. They are very hardy and stand our winters well. Their favorite haunts are low grounds near fields of grain, on which they depredate. They are very destructive to gardens as well. They nest in old straws tacks, stubble fields, or grass patches, beginning in May. Farmers while plowing often find their nests, take the eggs, set them under barn-yard hens, and raise the young easily. They become very domestic. I do not hear of their crossing. I have one that is a favorite with all who know him. His plumage is beautiful, having twenty-nine shades and colors blending over the body. The weight of the males is about 5 pounds; of the females, 4 pounds.

(2) The *Golden Pheasants* presented by Judge Denny to the Rod and Gun Club, of Portland, Oregon, two or three years later, were placed on Protection Island, Puget Sound, and have become numerous. A pair was set at liberty on the Clatsop Plains, near Astoria, where they have increased rapidly. Occasionally one is seen in our vicinity, about 90 miles from where they were turned loose four years ago. Yesterday I saw two pairs of Golden Pheasants a short distance from town. Their

habits are about the same as those of the Ring-necks. They are hardy, easily domesticated, but not as prolific as the Ring-neck. Their flesh is white and tender.

(3) The *Tragapan Pheasant.*—Only two females came through alive. They were turned loose on Protection Island with the Golden. I have not been able to get any account of what became of them after being turned out.

The above birds are all protected by State laws for two years longer, but in several of the counties they have become so numerous that farmers kill them as a nuisance. Report says that whole fields of wheat have been destroyed by them, and that gardens are torn up—not even onions being exempt from their appetities. Great complaints are made against them. The legislature of our State has been petitioned to repeal the law protecting them. (Letter dated January, 1889.)

Dr. F. S. Matteson writes from Aumsville, Marion County, Oregon, under date of January 22, 1889:

The bird in question was sent here from China by Hon. O. N. Denny, American minister to that country, some seven years ago. There were two importations, one of which I did not see, but I think there were fifteen or twenty hens, with a less number of males. Now they are plentiful in most parts of the Willamette Valley, but I am not informed that they have as yet passed outside of it. They are more a bird of open ground than the native Pheasant. They seek brush and timber for shelter when flushed, but will not "tree" for a dog. They usually make a loud cackling noise when flushed. They lie close, and run and hide with remarkable dexterity, and are a hard bird to get. This Pheasant is well adapted to take care of himself, is increasing fast, and has evidently come to stay. He is voted a nuisance by the farmer, and I am afraid his introduction will prove a calamity to the country, whatever it may be to the sportsman. He is a vigorous fighter, and there are many reports of his going through the farmers' roosters. Cases are reported of his crossing with the hens. He is destructive in gardens, and in patches of berries and small fruits. I am of opinion that he robs the nests of other birds. The Quail have nearly disappeared in this locality since his advent, and I think he is to blame. He is pretty good eating, about like our native Pheasant, but I am inclined to regard him as a gaudily painted deception and a fraud. But we have got him, and our State law for his protection has yet four years to run. Happily, however, it is fast becoming "more honored in the breach than in the observance." That he will overrun the United States, at least all but the heavily timbered portions of it, I have no doubt. All the plains country and untimbered hills and mountains between this coast and the Atlantic are adapted to him, especially the more southern parts, and I see nothing to prevent him from spreading himself. The State that protects him will make a grave error, for he is of no use except as a "game bird," and will crowd out many other useful kinds. He "roosts" on the ground, hiding in grass or weeds. The hen lays, on the ground, from twelve to eighteen eggs at a clutch, and raises two and sometimes three broods in a season. The male "crows" something like a young domestic rooster just learning the art, and flaps or rather flutters his wings *afterward.* He will sit on a fence and crow for hours, in plain view, when you have no gun, but if you think you can get him when you have your gun, try it and see!

Mr. R. S. Barr, also of Aumsville, Oregon, writes as follows:

In the spring the male goes alone. Mornings they crow like our common cock of the barn-yard. They hatch about the 1st of May. They are very destructive birds both to grain and small fruits. The Pheasant is naturally a tame bird. When not disturbed he often comes in the chicken yard and fights the chickens. It is generally believed that he destroys the eggs and young of useful native birds, but we have no proof of this. There is a law to protect him here, but it is generally disregarded by the people. (Letter dated January 24, 1889.)

Mr. George S. Johns writes that at Kalama, Wash., they are abundant and on the increase. It is evident that the birds found there came from the colony at the mouth of the Willamette River, only about 30 miles distant.

Mr. L. Belding, of Stockton, Cal., contributes the following:

Some years ago a flock of English Pheasants was put out in the woods of Santa Cruz County, Cal., but nothing has been seen or heard of them since. Colonel Haymond, of San Mateo, has a number of these birds, English and Japanese, but he has had no success in raising them; when let out they suddenly disappear and nothing is seen or heard of them. Mr. Howard, near by, has experimented with the same bird,

A few weeks since he informed me that his foreman told him he had seen a flock of twenty-two. The birds mentioned are the only ones experimented with. Certainly thus far the experiments in California are not a success. In Oregon they have met with great success.

The *Portland Oregonian* of January 30, 1889, contains the following letter from Hon. T. T. Geer in relation to the Pheasant legislation:

THE MONGOLIAN PHEASANTS.

SALEM, OREGON, *January* 29.

To the Editor of the Oregonian:

The *Oregonian* seems to misunderstand the main feature of the Mongolian Pheasant bill now before the legislature.

While the bill as introduced by myself does repeal the original act of protection, the game laws of the State are amended so as to afford the same protection to Mongolian Pheasants as to all other birds of similar nature.

Those of our people who are unused to these birds would upon further acquaintance view this bill in a different light. In the matter of "multiplying" they seem to regard themselves as having been specially included in the original biblical injunction, and are striving, in season and out, for first money. * * * You had just as well provide for the prevention of the extermination of grasshoppers; as a farmer, however, I not only have no objection to them but rather admire them, and would not for a moment favor a measure that would tend to act even as a check to their propagation.

In the *Sunday Oregonian* you admit that "in some places they do damage to grain fields," but excuse them for the reason that the damage "doesn't amount to much in the aggregate," and the inference is that they must be unmolested until their damage does amount to "much in the aggregate," and then the protection may be withdrawn safely.

It is a curious argument that confesses a thing to be a "nuisance" now by admitting that it injures a few of our farmers, but still insists that protection must be extended to it until it becomes strong enough to reach all our farmers and then turn loose.

I am a friend to the Mongolian Pheasants, and willingly favor giving them the same protection afforded our other birds, but where they are numerous enough to destroy grain fields it certainly ought to be lawful to kill them, and in those sections of the State where there are none it is not at all likely many will be killed. "I shall vote for the bill."

T. T. GEER.

THE MINK (*Lutreola vison*).

The Mink inhabits the whole of the United States, excepting the arid regions, which are unfitted for its habits of life. It is a species of great economic importance, both on account of the value of its fur and on account of its injurious habits. As an enemy to the poultry yard it ranks ahead of the Weasel and all other North American mammals. Furthermore, it kills large numbers of fish, as it not only swims and dives with facility, but can remain long under water, pursuing and capturing its prey by following it below the surface. Oftentimes its destructiveness in this respect renders it a serious obstacle to the industry of fish culture. Away from the vicinity of man it habitually feeds upon small mammals, birds and their eggs, fish, frogs, turtles' eggs, and the like. In the nest of a Mink I once found the remains of a muskrat, a red squirrel, and a downy woodpecker. Its harmfulness is offset in a measure by the good it does in killing injurious rodents, particularly muskrats and common rats and mice. Hence, although an acknowledged enemy to the poultry raiser and fish culturist, it is a public benefactor in localities where muskrats damage dikes, canals, irrigating ditches,

THE MINK (LUTREOLA VISON).

and ponds. At the same time, in the light of our present knowledge, it must be regarded as more injurious than beneficial, at least so far as the farmer is concerned. From the farmers' stand-point it is interesting principally as an enemy to barn-yard fowls. Though amphibious, and commonly inhabiting the borders of ponds and streams, it makes long excursions, and is frequently found in places remote from water-courses. It often takes up its abode in or near the poultry-yard or duck-pond, remaining there for weeks. Its small size and nocturnal habits help to conceal its movements, and the daily loss of a fowl is commonly attributed to the skunk, fox, weasel, or owl.

The Mink is remarkably strong for so small an animal, and has been known to drag a Mallard Duck more than a mile in order to get to its hole, where it was joined by its mate.

In times past, when the fur of the Mink commanded a higher price than at present, Mink farming has been carried on successfully as a profitable industry. The females begin to breed when one year old; the period of gestation is six weeks, and from three to ten young are born at a time. In the latitude of New York there is but one litter a year, and this is brought forth in the early part of May.

The best way to capture a Mink is by means of a steel trap, properly concealed and baited with a bird or fish. Professional trappers find the Mink attracted by the smell of an oil made from fish that have been allowed to decay in a loosely corked bottle placed in the sun. The odor from this oil is said to be effective at considerable distances, and a few drops of it will often entice a Mink into the trap when no bait is visible.

The following examples of testimony from farmers and others indicate the extent of its depredations:

Dr. William C. Avery, or Greensborough, Ala., writes that in the spring of 1887 the poultry house of his sister was visited two or three times a week by a Mink until at least a dozen hens were killed.

David H. Henman, of Willows, Dak., writes that in December, 1886, a Mink killed all of his hens in one night. He says:

The third night he killed the cock, and I found him in the hen-house the next morning taking his breakfast. One of my neighbors lost fifty-one fowls in one night by one Mink, which was found in the morning finishing his meal; he was killed with a stick; only two chickens were left alive.

William H. Ferrit, of Bristol, Ill., says:

The Mink is the worst enemy to poultry that we have. He follows up small streams and destroys thousands of eggs and poultry.

W. H. Head, of Bristow, Iowa, says:

In January, 1887, a Mink visited the poultry house of my brother, and in one night killed eighteen full-grown fowls. The hen-house is about 40 rods from a large marsh where Minks are plentiful. During the past winter my brother lost more than one hundred fowls from these pests. We once set a large Cochin hen in the banking of an old straw stable. This was some time in June. Early one morning I observed a large Mink near the stable. A few days later I examined the nest. There was but one egg left. The next morning I went to the stable and found the hen missing. Reaching back into a hole behind the nest, and feeling the hen, I pulled her out. She was dead, with a hole in her neck which the Mink had made to suck her blood. The next day my brother shot the Mink. We then took away the banking of the stable and found most of the eggs unbroken, and also found five young Minks.

John B. Lewis, of Eubank, Ky., writes:

In the summer of 1884 I lost seven chickens in one night by a Mink. The night following I caught the Mink on its return to the hen-house. Again on the night of

November 16, 1887, a Mink entered our hen-house and killed one hen. The following night I killed it on its return.

William G. Voorheis, of South Frankfort, Mich., writes:

One Mink killed thirty-nine hens in three nights. I caught the animal.

G. C. Dinsmoor, of Austin, Minn., writes:

I had five ducks and two hens killed by a Mink; caught him in the act.

N. W. Wright, of Farmland, Ind., writes:

I have known a Mink to kill as many as twenty-four grown chickens in one night in this neighborhood. It was caught in a trap on its return the next night.

H. J. Giddings, of Sabula, Iowa, writes:

In September, 1886, a Mink got into my poultry house and killed ten ducks and twelve chickens, killing from two to eight in a night. I caught him, after which no more were taken.

W. B. Hall, of Wakeman, Ohio, writes:

The past season Minks have been very troublesome on my farm, killing many chickens, often several in a night. They killed fifteen chickens that would have weighed 3 pounds or more. In another week ten more were killed. Since then we have lost two or three more at a time, until in all about forty-five were killed. I have tried various means of trapping, and have finally succeeded in getting rid of most of the Minks.

Mr. George S. Johns, of Dilley, Oregon, writes:

I have known one Mink to kill thirty-one grown chickens in one night, and another Mink to kill sixteen half-grown turkeys in one night. I caught the Mink on both occasions.

A. J. Johnson, of Hydeville, Vt., writes:

This season a friend lost nearly all of his chickens and ducks by Minks. His poultry house was near the river, and the animals were seen by him.

Marcus S. Crane, of Caldwell, N. J., writes:

A Mink dug a hole under the door of our duck pen one night and killed three ducks. I put a steel-trap in the hole next night and captured the Mink.

Hon. Robert B. Roosevelt, of Sayville, Long Island, N. Y., writes:

In the course of a week I lost seven spring chickens and caught the Mink which killed them. We have suffered in a similar way from Minks before.

J. W. Van Kirk, of Milton, Pa., writes:

On one occasion I lost eight ducks by a Mink: each one was bitten in the neck.

J. W. Johnson, of Meriwether, S. C., writes:

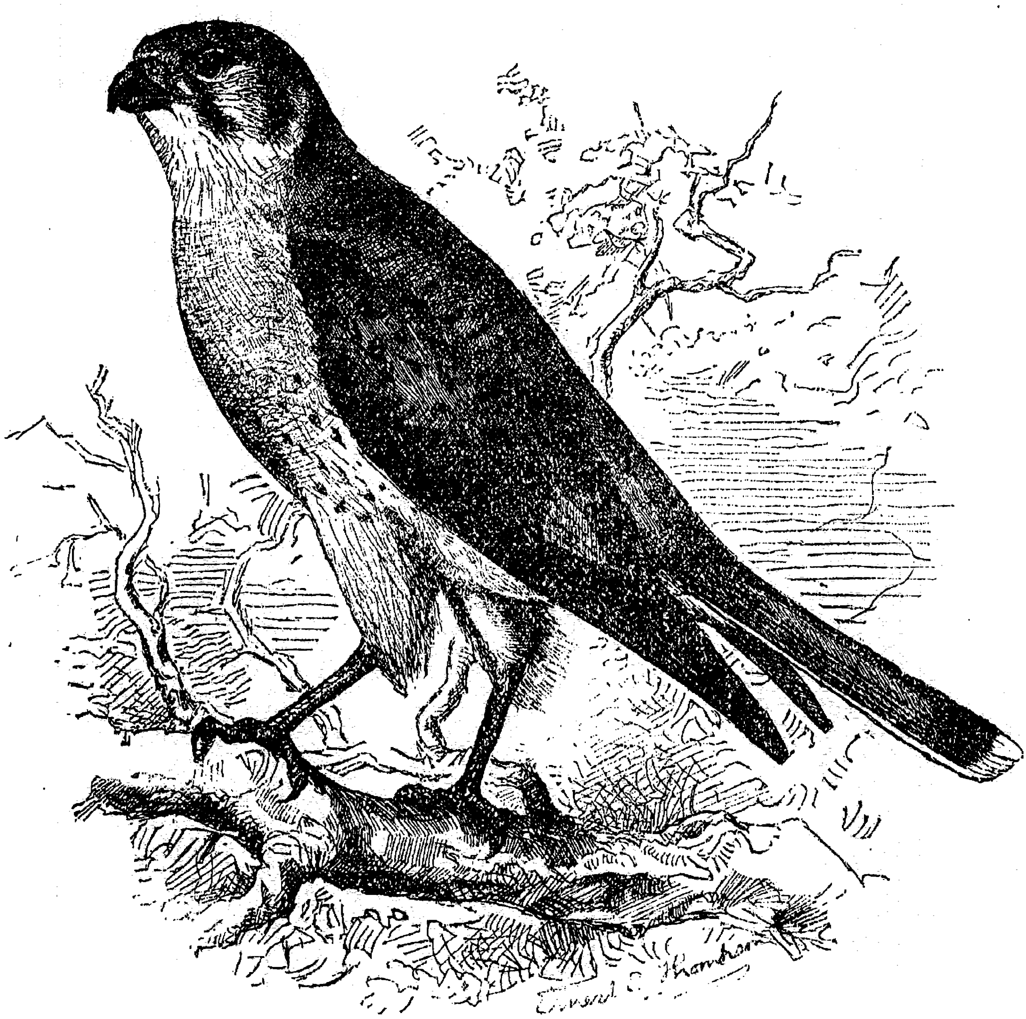
When Minks are numerous they are very destructive, sometimes killing as many as a dozen chickens in one night.

J. H. Shank, of Hickory, W. Va., writes:

Minks are very destructive to chickens, killing sometimes as many as a dozen in one night.

Z. L. Welman, of Stoughton, Wis., writes:

A neighbor lost a flock of ducks by a Mink, which he killed. Another neighbor lost a dozen hens by a Mink; he killed it also.



THE SPARROW HAWK (*Falco sparverius*).

By Dr. A. K. Fisher.

The Sparrow Hawk is probably the best known as well as the smallest and one of the handsomest of American hawks.

It ranges over the entire continent of temperate North America, breeding in suitable localities from Maine to California, and from the fur countries south into Mexico. Its nest has been taken as far north as Fort Resolution (lat. 62°), on Great Slave Lake, which probably is near the most northern limit of its distribution. It is reported as rare in most parts of New England, though there are certain sections where it is fairly common. In the mountains of the West and in most parts of the South it is abundant, and at certain times of the year is common on the Great Plains. In winter a few hardy individuals remain in southern New England and New York, but the species as a winter resident is not common until the latitude of Maryland and Virginia is reached; thence southward it becomes more and more plentiful. In the Mississippi Valley it does not range quite so far north in winter as along the Atlantic, for few are found above the 38th parallel. Along the Pacific coast it winters considerably further north than at the East.

This little Hawk guards the vicinity of its home or hunting ground

with zealous care, resenting the invasions of the larger species. The writer has often seen a Red-tailed or Red-shouldered Hawk enter a locality in which a Sparrow Hawk was perched on the top of some tall tree, evidently thinking he had a prior right to the whole region. As soon as the large hawk approached near enough, the Sparrow Hawk launched out in pursuit, and in a very short time the intruder was convinced that hunting could be carried on to better advantage in other places. In making an attack the Sparrow Hawk always rises above its enemy and darts down, striking with bill and talons.

In a locality where it is very little molested it is quite tame and unsuspecting, often allowing a person to approach as near as 20 yards before taking wing, and when flushed it flies but a short distance. It is quite another matter to advance upon one in places where it is more or less hunted. Experience seems to have taught it just how far a gun will carry, and generally it will leave the perch just before an effective point is reached. After following it for an hour or more and taking a few chance shots, the gunner usually gives up in disgust and leaves the hawk in as good spirits as when first seen.

The Sparrow Hawk builds its nest in hollows of trees, either in natural excavations which are formed by erosion of the dead wood by the elements, or in holes made by the larger woodpeckers. If the flicker (*Colaptes*) is the bird imposed upon, which is most often the case, it never openly battles with the hawk for the retention of its home, but sometimes annoys the latter by removing the nesting material as fast as it is deposited, making it finally necessary for one of the hawks to remain near to guard the nest.

The cavity chosen is usually a considerable distance from the ground, rarely under 20 feet and often in the tops of the highest trees. In the West, on account of its mode of nesting, the species is more or less restricted in the breeding season to the near vicinity of timber, though in some localities it nests in cavities in limestone cliffs or in holes made by kingfishers in the sand banks. It has been stated that occasionally the deserted nests of crows or other birds are made use of, but this habit must be extremely rare. Capt. Charles E. Bendire, whose field experience in the West has been extensive and varied, and often in places where birds by force of circumstances are not able to follow a fixed habit, informed the writer that on one occasion only did he suspect this hawk of breeding in an open nest. In the case in point the evidence was anything but satisfactory, for although the birds were seen near the nest, which was situated in a very large tree, he thought there might have been a cavity which was not visible from the ground. In California, Prof. B. W. Evermann has found it using the deserted nest of the magpie (Auk, vol. iii, p. 93). This is not so strange, for we might expect the entrance in the side of the canopied nest of the magpie, simulating an opening in the side of a tree, would attract the hawk, especially in a locality where desirable hollows are scarce.

Dr. William Wood mentions the following interesting instance of departure from its usual nesting habit:

> A farmer made a dove-house inside of his barn with holes through the sides of the building communicating with it. A pair of doves that had nested there were attacked and killed by a pair of Sparrow Hawks, who took possession of their nest, laid four eggs, and commenced to sit. (American Naturalist, Vol. VIII, No. 5, p. 268, May, 1874.)

In Florida it commences to breed early in March; in the latitude of New York about the middle of May, and in the northern part of

its range it is probably June before the eggs are deposited. The number of eggs in one nest is usually five, rarely more.

Its ordinary flight is irregular and not long continued. Even in migration it often stops to rest on a tree top or fence post, where it may remain a considerable time. Still it is capable of very rapid flight. It rarely if ever soars as do most of the other hawks. Sometimes it makes a succession of rapid beats of its wings and sails for a short distance, but usually, when in search of food, instead of circling, it hovers, remaining stationary with rapid-moving wings. If it perceive its quarry it drops to the ground to seize it, and, if successful, bears it away to a neighboring stub or fence pole to devour.

Food.—The subject of the food of this hawk is one of great interest, and considered in its economic bearings is one that should be carefully studied. The Sparrow Hawk is almost exclusively insectivorous except when insect food is difficult to obtain. In localities where grasshoppers and crickets are abundant these hawks congregate, often in moderate-sized flocks, and gorge themselves continuously. Rarely do they touch any other form of food until, either by the advancing season or other natural causes, the grasshopper crop is so lessened that their hunger can not be appeased without undue exertion. Then other kinds of insects and other forms of life contribute to their fare; and beetles, spiders, mice, shrews, small snakes, lizards, or even birds may be required to bring up the balance. In some places in the West and South telegraph lines pass for miles through treeless plains and savannahs. For lack of better the Sparrow Hawks often use these poles for resting places, from which they make short trips to pick up a grasshopper or mouse which they carry back to their perch. At times, when grasshoppers are abundant, such a line of poles is pretty well occupied by these hawks.

A dozen or more stomachs collected by Mr. Charles W. Richmond, in Gallatin County, Mont., during the latter part of August and early part of September, 1888, were kindly turned over to this Division for examination. They contained little else than grasshoppers and crickets.

Mr. W. B. Hall, of Wakeman, Ohio, writes to us on the subject as follows:

> The Sparrow Hawk is a most persistent enemy of the grasshopper tribe. While the so-called Hawk law was in force in Ohio, I was township clerk in my native village and issued certificates to the number of eighty-six, forty-six being for the Sparrow Hawk. I examined the stomachs and found forty-five of them to contain the remains of grasshoppers and the elytra of beetles, while the remaining one contained the fur and bones of a meadow mouse (*Arvicola riparius*).

The following from the pen of Mr. H. W. Henshaw substantiates what we have said in regard to their fondness for grasshoppers:

> It finds * * * an abundant supply of game in the shape of small insectivorous birds; but more especially does its food consist of the various kinds of coleopterous insects and grasshoppers, of which it destroys multitudes. In fact, this last item is the most important one of all, and where these insects are abundant I have never seen them have recourse to any other kind of food. (Zool. Expl. West of 100th Merid., Vol. v, 1875, p. 414.)

The late Townend Glover, formerly Entomologist of the United States Department of Agriculture, states that the beneficial traits of this hawk more than counterbalance any harm it may do, and says:

> In proof of this, a Sparrow Hawk, shot in October, among a flock of reed or rice birds, was found to be filled with grasshoppers, and contained not the slightest vestige of feathers or bones of birds. This bird was remarkably fat. (U. S. Agric. Report, 1865, p. 37.)

Mr. C. J. Maynard, writing on the food of the Sparrow Hawk at Miami, Fla., says:

> They have nothing to do but to pick up grasshoppers, of which they appear never to tire. It is true that they can find green grasshoppers and brown grasshoppers, grasshoppers with wings and wingless grasshoppers, but still, as far as any distinctive taste is concerned, there must be but little variation. Yet to all appearances the hawks are satisfied, for I never saw one take any other kind of food. (Birds of Eastern North America, 1881, p. 297.)

In the vicinity of Washington, D. C., remarkable as it may appear to those who have not interested themselves specially in the matter, it is the exception not to find grasshoppers or crickets in the stomachs of Sparrow Hawks, even when killed during the months of January and February, unless the ground is covered with snow.

It is wonderful how the birds can discover the half-concealed, semi-dormant insects, which in color so closely resemble the ground or dry grass. Whether they are attracted by a slight movement, or distinguish the form of their prey as it sits motionless, is difficult to prove, but in any case the acuteness of their vision is of a character which we are unable to appreciate.

Feeding on insects so exclusively as they do, it is to be presumed that they destroy a considerable number of beneficial kinds, as well as spiders, which they find in the same localities as the grasshoppers. However, examination of their stomach contents shows the number to be so small, compared with that of the noxious species, that it is hardly worth considering.

After the severe frosts of autumn and in winter, when insect life is at its lowest ebb, the Sparrow Hawks devote more time to the capture of mice and small birds. As a rule, the birds which they capture at this time are ground-dwelling species, which simulate the movements of mice by running in or about the dry grass and weeds. They are mostly sparrows, more or less seed-eating, and hence not among the species most beneficial to the agriculturist. At this season it is common to see Sparrow Hawks sitting on the poles over hay stacks, or stationed where they can command a good view of the surroundings of a hay mow or grain crib, ready at any moment to drop upon the mouse which is unfortunate enough to show itself. In this way they manage to destroy a vast number of mice during the colder months.

In the spring, when new ground or meadow is being broken by the plow, they often become very tame if not molested. They fly down, even alighting under the very horses for an instant in their endeavor to capture an unearthed mouse or insect.

The following letter from W. P. McGlothlin, of Dayton, Columbia County, Wash., dated February 12, 1887, contains some interesting facts on this particular subject:

> There is a small hawk here called the Sparrow Hawk. It comes about the 1st of March and leaves with its young about August 1st. On their arrival they are in large flocks and seem very hungry. I have had a number follow my team all day long and even alight for a moment on the plow beam. When a mouse was unearthed it was captured in an instant and quickly killed. The hawks seem to know just when their victims are dead. They settle on something suitable to their fancy and commence eating the eyes, and then soon finish. For two weeks this mouse catching goes on. I have sometimes seen them chase and catch small birds. They pair off and drive some woodpecker from his cozy nest in an old tree, where they lay from four to six eggs. When they have young the small chickens must suffer. About two each day for every nest seems to satisfy them.

Mr. Thomas McIlwraith, in his "Birds of Ontario," gives the following on the food of this hawk:

Though sometimes seen near the farm-house it does not bear the stigma of having felonious intentions towards the occupants of the poultry yard, but is credited with the destruction of large numbers of mice. * * * It also feeds freely on snakes, lizards, grasshoppers, etc., but has the true falcon etiquette of taking only what is newly killed (p. 150).

In the opinion of many people, unaccountable as it may appear, the benefit accruing from the destruction of a great number of mice or other injurious mammals or insects by hawks does not offset the damage done by the capture of one bird or chicken. This, of course, is not the case with those intelligent farmers who recognize the benefit done by this little hawk, and are not prejudiced against it if it exacts a moderate interest now and then in the shape of a young chicken or bird. In May and June, when the hawks are busy hatching their eggs and rearing their young, there is less time for them to procure their favorite food. It is during this period, as we might expect, that a very large proportion of the birds which they capture in the course of the year is taken. It is also at this time that we hear complaints of their depredations in the poultry yard. Sometimes they take young birds from the nest, for Mr. Austin F. Park, of Troy, N. Y., mentions the finding of unfledged birds among their stomach contents. From the following note it may be seen that occasionally they take also old birds from the nests:

In Elizabeth, N. J., several years ago, I saw a pair of Sparrow Hawks fly up under the eaves of an old barn and drag a couple of swallows out of their nests. (Merriam, Review of the Birds of Conn., 1877, p. 85.)

That the Sparrow Hawk at times attacks and kills comparatively large birds is vouched for by Dr. Coues, in his Birds of the Northwest. He says:

I have seen it overpower and bear away a thrasher, a bird inch for inch as long as itself, and nearly as heavy.

And we have found remains of the meadow lark in the stomachs examined.

In the accompanying table a summary is given of the food of the Sparrow Hawk, arranged according to months. It is based upon data derived mainly from the examination of stomachs made by myself in the Department of Agriculture.

It is to be regretted that during certain months, notably May and June, we were unable to obtain more specimens for examination. The available number is so small that the result here given probably would be totally changed by the addition of a dozen specimens to each of these two months.

Of the one hundred and sixty-three stomachs examined, not one contained the remains of poultry. Thirty-one birds were found, of which twenty were various species of sparrows, three were meadow larks, one was a vireo, one a warbler, one a quail,* and five could not be determined as the feathers and other parts were too much broken up to admit of identification.

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*This record of finding the remains of a quail in the stomach of a Sparrow Hawk is given second hand, from an examination made in Nebraska. We strongly suspect, unless the quail was a very young bird, that one or the other small hawks was mistaken for the Sparrow Hawk.

Table giving a summary of food of the Sparrow Hawk, arranged according to months.

Months.	No. of specimens examined.	Birds.	Mice or other mammals.	Reptiles and batrachians.	Insects.	Remarks
January	27	7	24	....	52	
February	12	2	8	....	29	1 empty.
March	17	3	8	1	41	3 empty.
April	12	1	7	3	75	1 empty.
May	2	1	1	....	4	
June	3	3	....	....	*76	
July	18	2	8	....	177	
August	19	....	5	2	263	
September	18	1	2	2	271	
October	7	....	1	....	31	
November	5	....	1	....	12	
December	23	11	14	....	96	
Total	163	31	79	8	1,125	5 empty.

For convenience, spiders have been enumerated with the insects.

THE SHORT-EARED OWL (*Asio accipitrinus*).

By Dr. A. K. FISHER.

The Short-eared Owl is a bird of extended distribution, ranging over the greater part of both hemispheres. In Africa it has been found as far south as Abyssinia in winter. It has not been recorded from Australia. In a northerly direction it reaches the southern

part of the Arctic regions, whence southward it probably breeds more or less commonly in favorable localities throughout its range.

The nest is a rough affair made of coarse grass and sticks, loosely drawn together and sparsely lined with fine material and feathers from the parent bird. It is placed on the ground, often in a depression made to receive it, under some bush or among high grass. In exceptional cases it has been found in a clump of low bushes, or otherwise slightly elevated. The eggs, from three to five in number, are deposited in April or May, according to the latitude of the nesting ground.

The Short-eared Owl is pre-eminently a bird of the open country, including the coast marshes and islands covered by bushes and high grass. In the United States it is much more common in winter, when it receives large reinforcements from the North. During this season of the year single individuals are usually met with, and less often small colonies, composed of four or five birds. Possibly these are families which have never been separated, having migrated in company from their nesting grounds.

The food of this owl consists largely of mice and other small mammals. A number of species of insects, birds, and reptiles also may be mentioned as occasionally contributing to its fare. Fully 90 per cent. of the stomachs examined in the Department of Agriculture contained nothing except meadow mice. The remains of as many as five mice were found in one stomach, and several contained three or four each. Prof. F. E. L. Beal reports finding nothing but mice in the stomachs of a pair which he killed in Story County, Iowa. They were shot in an artificial grove swarming with small birds.

Mr. Austin F. Park, of Troy, N. Y., in a report on the food of Hawks and Owls, which he kindly sent to this Department, mentions mice and no other kind of food as found in the stomachs of this species.

Of the other mammals which this owl feeds upon may be mentioned shrews, gophers, and sometimes small rabbits. Shrews are not uncommon in the stomach contents. Dr. J. C. Merrill, in mentioning the food of this bird at Fort Klamath, Oregon, says:

> In one specimen a pellet ready for regurgitation contained ten nearly perfect skulls of a shrew, a species of which, and field mice, were nearly always found in the stomachs. (Auk, Vol. v, April, 1885, p. 146.)

Unfortunately we have been unable to procure stomachs of this owl from the Western plains which are infested with ground squirrels and gophers, hence we do not know to what extent it feeds upon these rodents. It does not feed as extensively on insects as either the Barred or Screech Owls, but there are reports enough on the subject to show that grasshoppers, crickets, and beetles at times form a considerable portion of its food. It is quite exceptional for this owl to feed upon birds. Out of about fifty stomachs examined by us at the Department not over four contained bird remains.

Only once have we found more than one bird in a single stomach. This was in a specimen shot in the vicinity of Washington, D. C., late in November; it contained the remains of two Juncos and one Fox Sparrow.

A notable violation of its usual habit of feeding upon mice may be quoted from Mr. William Brewster as follows:

> A small colony of these birds had established itself upon a certain elevated part of the island [Muskegat], spending the day in a tract of densely matted grass.

Scattered about in this retreat were the remains of at least a hundred Terns that they had killed and eaten. Many of these were fresh, while others were in every stage of decomposition, or dried by the sun and wind. In each case the breast had been picked clean, but in no instance was any other portion disturbed. Every day at a certain time these owls sallied forth in search of fresh prey. We used regularly to see them about sunset, sailing in circles over the island or beating along the crests of the sand-hills. They were invariably followed by vast mobs of enraged Terns, which dived angrily down over the spot where the Owl had alighted, or strung out in the wake of his flight like the tail of a comet. The Owl commonly paid little attention to this unbidden following, and apparently never tried to seize his persecutors while on the wing, but on several occasions we saw a sitting bird pounced upon and borne off. Sometimes in the middle of the night a great outcry among the Terns told where a tragedy was being enacted. (Bull Nutt. Ornith. Club, Vol. IV, p. 19).

The following important evidence of the economic value of the Short-eared Owl is from the fourth edition of Yarrell's British Birds (Vol. IV, p. 165):

Undoubtedly field-mice, and especially those of the short-tailed group or voles, are their chief objects of prey, and when these animals increase in an extraordinary and unaccountable way, as they sometimes do, so as to become extremely mischievous, owls, particularly of this species, flock to devour them. Thus there are records of "a sore plague of strange mice" in Kent and Essex in the year 1580 or 1581, and again in the county last mentioned in 1648. In 1754 the same thing is said to have occurred at Hilgay, near Downham Market, in Norfolk, while within the present century the Forest of Dean, in Gloucestershire, and some parts of Scotland have been similarly infested. In all these cases owls are mentioned as thronging to the spot and rendering the greatest service in extirpating the pests. The like has also been observed in Scandinavia during the wonderful irruptions of lemmings and other small rodents to which some districts are liable, and it would appear that the Short-eared Owl is the species which plays a principal part in getting rid of the destructive horde. An additional fact of some interest was noticed by Wolley, namely, that under such circumstances the owls seem to become more prolific than usual.

THE FOOD OF CROWS.

By WALTER B. BARROWS, S. B., *Assistant Ornithologist.*

The economic status of the Common Crow (*Corvus americanus*) has been discussed so often, and yet with such uncertain results, that it was one of the first birds to receive attention when the Division was organized in 1885, being particularly mentioned in the circular issued that year. Several hundred replies to the questions contained in that circular were received during that and the following year, and much additional information was collected by subsequent correspondence. A request for stomachs of the Crow was contained in the circular issued in 1886, and although the responses to this have not been as numerous as could be desired, a number of correspondents have given material assistance, so that it is possible to append to the present paper the results of the dissection of eighty-six stomachs of the Common Crow (*Corvus americanus*) and twelve of the Fish Crow (*Corvus ossifragus*). Thus the material at hand for a study of the food of Crows, though by no means abundant, is nevertheless considerable, and sufficient progress has been made in its investigation to justify the publication of some of the results. One of the main objects of the present paper, however, is to call the attention of farmers and others to the disputed and unsettled questions relating to the Crow and to secure their aid and co-operation in collecting evidence which will hasten a final settlement of these points.

It is unnecessary at the present time to refer to the numerous con-

tributions to our knowledge of the Crow's habits made from time to time during the last century, but it may be broadly stated that but three strong points in its favor have ever been claimed for the Crow even by its warmest friends: These are (1) the habit of destroying injurious insects; (2) the habit of catching mice; and (3) the habit of eating carrion. A few writers, mainly men of very limited experience, have maintained, it is true, that the Crow never does any harm worth mentioning; but the more rational of his defenders admit freely that a large amount of damage is done, but claim that this is more than compensated by the good habits just specified. Of these, the carrion-feeding and mouse-eating habits have been the weaker arguments, and the place of the Crow as a beneficial bird has rested mainly on the ground of its supposed services in the destruction of noxious insects.

On the other hand, the injuries inflicted by the Crow are more varied, those most commonly complained of being:

(1) Destruction of young grain, particularly Indian corn on first coming up.

(2) Destruction of ripe or ripening corn and other grain.

(3) Destruction of ripe or ripening fruits of some kinds.

(4) Destruction of various other vegetable products.

(5) Destruction of the eggs and young of poultry.

(6) Destruction of the eggs and young of wild birds.

Nearly every one in the least familiar with the habits of the Crow will readily admit that the bird is more or less beneficial or injurious in the ways indicated above, but the greatest diversity of opinion exists as to the degree of benefit or injury to be assigned to each category.

The Division has succeeded in bringing together a large amount of *opinion* on these points, and a considerable amount of what may be regarded properly as *evidence*. Moreover, some additional charges against the Crow have been preferred and some further claims of merit are brought forward. Statements of mere opinion carry little weight unless the facts on which these opinions are based are fully known. On the other hand, the careful record of any actual experience with the Crow is entitled to thoughtful consideration, the weight to be given to such evidence being modified only according to the known fitness or unfitness of the observer to appreciate all the elements entering into the case.

As the entire question relates primarily to the *food* of the Crow, it is obvious that the careful examination of a sufficient number of Crow stomachs would be the only certain method of settling all questions; but the number of stomachs required necessarily would be very great, and in order fully to weigh the evidence thus afforded, full notes as to locality, date, time of day, character of place where killed, age of bird, etc., are indispensable.

About one hundred stomachs, accompanied by such data, have been carefully examined thus far, and a summary of the facts revealed will be found on a following page. Unfortunately, however, most of these stomachs were those of adult Crows, and very few of them were taken during the spring and early summer, when the Crow is supposed to be most beneficial.

It has proved more difficult than was expected to secure Crows during the spring and summer months, but a special effort will be made during the season of 1889, and it is hoped that a large number of stomachs may be collected and examined. Those of young Crows

are particularly desired, but those of Crows of any age if taken during spring or summer will be very acceptable. Persons willing to aid the Division in this way will be furnished with instructions and materials on application to the ornithologist, and all costs of transportation will be defrayed by the Department.

In response to questions relating to the food habits of Crows replies have been received from upwards of five hundred persons, and the information afforded by these replies, in combination with the results of dissection, form the basis of the following report.

DISTRIBUTION OF THE CROW.

The Common Crow (*Corvus americanus*) occurs in variable abundance throughout the whole of the United States; most numerously, perhaps, east of the one hundredth meridian, though it is far from uncommon in California. In most of the Rocky Mountain region it is rather scarce.

Although the larger number migrate southward in winter from the northern tier of States, returning again in earliest spring, probably a few spend the entire winter at the north, even in northern Minnesota and Wisconsin. In the lower half of the Mississippi Valley, however, and in the Middle Atlantic and Gulf States millions of Crows remain from November to March; collecting in some localities in immense flocks, repairing regularly to favorite places to pass the night, and scattering over the surrounding country during the day. In the breeding season they are distributed more evenly, and notes on their food habits have been received from all parts of the country.

Along the Atlantic coast, from Long Island to Florida, another species, the Fish Crow (*Corvus ossifragus*) is found associated with the Common Crow, and the two species are so nearly alike in general appearance and habits that at gunshot range even a practiced ornithologist can not always separate them. But the Fish Crow averages decidedly smaller than the Common Crow, has a different voice, and when in hand is otherwise readily distinguished by one accustomed to study birds. Probably a few notes from the Atlantic seaboard may refer to this species instead of to the Common Crow, but this will not affect materially the questions under consideration. In the detailed report of the examination of stomachs the two species are treated separately.

INJURY TO INDIAN CORN, WHEAT, AND OTHER CEREALS.

It seems almost superfluous to say that the Crow at certain times and places is very destructive to crops of sprouting grain, for its corn-pulling habits were well known even in colonial times, and from that day until the present, wherever the bird is at all abundant, a newly planted corn-field without scare-crows has been the exception and not the rule. Doubtless the destruction is greatest during the first week or two after the corn appears above ground, but if all reports are to be credited considerable harm is done by digging up the seed-corn directly after planting, even before the grain has begun to germinate. One observer states that the Crow eats corn "from ten minutes after planting until the blades are three inches high," and more than a score of other observers state definitely that the Crow not only pulls up the young plants, but *digs* up the newly sown seed. Several observers

state that the Crow *scratches* up planted grain, but this probably is a mistake, for such a habit has never come to our notice, and it would seem to be entirely foreign to the nature of the bird. Crows are known to watch the operation of corn-planting, occasionally with evident interest, and many a farmer knows that any grain left uncovered is likely to be eaten at once. In some cases it is even unsafe to allow the corn to be dropped much faster than it can be covered, since the observant Crow plunders the hill before it is made. It is but natural to suppose that so intelligent a bird as the Crow would be able to locate the hills after the planting is done, and to unearth with the bill any grains which have been but lightly covered. This is all the more likely in the case of birds which have been watching the planting and have picked up the scattered grains left entirely uncovered, especially if the farmer has followed the time-honored custom of stamping or "firming" the center of the hill with the head of the hoe.

Among the reports bearing upon this point are the following:

From George H. Berry, North Livermore, Me.:

The Crows dig corn before it breaks the ground, and do great damage pulling the young corn and also digging potatoes.

From G. Douglas Robertson:

While resident in southeastern Nebraska I have heard farmers complain that the Crow picked the kernels of corn out of the ground just after planting, and know that when the corn commenced to come up the ground was bare in many places, but whether this was the fault of the Crows or of the machine that planted it I can not say.

From W. T. Craig, San Francisco, Cal.:

In Santa Cruz County Crows were observed to eat the corn while planting, and they continued to do so until it was three inches high, pulling it up and feeding upon the grain attached to the rootlets. They destroyed four or five acres, and were then driven away.

From C. W. Costellow, Waterborough, Me.:

Crows dig up and eat corn as soon as it is planted, and continue to do so until the growing spears absorb the kernel. Occasionally in the same way they dig up and eat potatoes just planted.

While these and similar reports seem to show that in some cases the Crow actually digs up the seed even before it germinates, many trustworthy witnesses state that they have never known it to unearth well-covered grain until the sprout appeared at the surface. This, however, is merely negative evidence and only tends to show that the former habit is far less general than the latter.

As has been suggested by more than one observer, the Crow is often blamed for the work of the chipmunk, the latter being known to dig up the newly planted kernels very frequently, especially along the edges of fields near woods. But the chipmunk does not extend his raids far from the edges of the field, and, moreover, he is not known to dig up newly planted potatoes, so that the dozen or more reports which charge the Crow with this last offense give additional weight to the testimony relating to the digging up of corn. Any one who has an opportunity to make exact observations on this question will confer a favor by communicating the results to the Department.

The manner in which the Crow attacks corn which is just coming up is but too well known to most farmers, yet perhaps few of them have actually seen it pull the young shoots from the ground, and doubtless there are many who still disbelieve that the object of the

pulling is simply the swollen grain at the root. From several hundred reports of damage to young corn, we select a few to show the way in which the harm is done.

Byron J. Peckham, of Westerly, R. I., wrote in 1885:

Corn seems to suffer most because the Crows get a large amount for little labor. Their *modus operandi* is to wait until the corn has shown itself above the ground and then pull it and devour the kernel at the roots. The injury done consists largely in the trouble of replanting at a time when other work demands the attention of the farmer.

F. K. Steele, of Annapolis, Md., says:

As the young shoots peep out of the ground the Crow may be seen digging them up. From the time of their first appearance above the ground until the kernel has been absorbed by the growing plant it is destroying the crop. This period lasts two or three weeks, according to the quickness of the growth of the grain.

The injury consists of an uneven stand, requiring replanting. This seldom pays for the trouble, since the corn which was not disturbed by the bird has the start and occupies all the soil with its roots; therefore the replanted corn grows slowly and spindling, and makes fodder principally.

J. M. Nipp, of Bolton, Mo., gives the following interesting account of one of his observations:

But few Crows learn to pull up corn, but one that does will pull ten hills per minute. June 27, 1884, I planted three acres of corn on wheat stubble, the wheat having been hauled away. Ten days after planting I saw eight Crows in the field; from appearances they were two parents and six young. One was pulling the corn, one standing idle, and six eating the grain after it was pulled up. I watched them about forty minutes, and then went and counted the fresh pulled stalks where they had been; there were four hundred. One-third of the three acres was taken at that time. I then supplied them with wheat in the bundle, and no more was taken.

The amount of damage to corn during spring and early summer is certainly very great in some sections, and undoubtedly it would be much greater but for the almost universal custom of protecting the fields in one way or another. Of course, it is absurd to say how great the loss *would be* in case all precautions were neglected, and even in the case of actual damage it is impossible to estimate fairly the amount of the loss. Among nearly two hundred and fifty reports of more or less serious injury, less than one-fifth contain any figures from which the actual loss can be inferred even approximately, while hardly a dozen state definitely the acreage planted and the proportion destroyed or damaged.

The following examples of the evidence on this question will give a fair idea of the harm *occasionally* done. It will be noticed that they represent widely separate sections of the country:

Osceola, Ark.—One flock ruined a field of several acres.

Coventry, Conn.—In one field of three acres about half was destroyed; other fields badly damaged, probably one-third pulled up.

Osceola, Ill.—Destroyed about two acres for me last year (1885) just as it was coming through the ground.

Plymouth, Me.—Has been observed to destroy whole fields of from one to three acres.

Rochdale, Mass.—Crows this year (1885) pulled one-third or more of the corn in my fields in spite of cotton lines stretched quite thickly over the fields.

Nebraska, Ind.—Have known the injury to amount to one-third of the crop.

Burlington, Iowa.—Have known one-third of a five-acre field to require replanting.

Sand Hill, Mich.—Often destroys over half the crop when planted near a patch of woods. Fields sometimes are nearly destroyed.

Bolton, Mo.—One-third of a field of three acres was taken.

Madison, Nebr.—The damage along the woodlands of the Elkhorn is ten per cent. of the planting.

Caldwell, N. J.—Damage often from one-tenth to one-third of the field.

Alfred Centre, N. Y.—Sometimes they make a second planting necessary; in one case a field of three acres was almost entirely pulled up.

Ithaca, N Y.—In spite of all our efforts they almost destroyed the crop in a large part of one field.

Locust Grove, N. Y.—In 1884 a large field was ruined by Crows in spite of all precautions. It was "strung" at more frequent intervals than usual, a number of dead Crows were displayed at various points, and it was replanted twice, but all to no avail, for almost the entire field was lost.

Penza, Ohio.—Once saw a field on the 4th of July which had been destroyed four times by Crows, and they were still working on it.

Gap, Pa.—Think they sometimes destroy five per cent. of the crop.

Frogmore, S. C.—The damage sometimes amounts to over 50 per cent., but this is only in fields near woodland.

Brandon, Vt.—One-half to three-fourths of an acre was pulled from a three-acre field.

West Pawlet, Vt.—In 1883 and 1884 I knew the Crows to pull the corn so completely in fields of ten or twelve acres that all the ground had to be planted over.

Omro, Wis.—One piece of four acres was about two-thirds destroyed.

The ten following samples may be taken as showing more nearly than the preceding the *average* character of the reports noting damage to young corn:

Smelley, Ala.—Much damage some years, others none at all.

Brookfield Centre, Conn.—A small piece in a secluded spot was almost entirely destroyed.

Vermillion, Dak.—In some fields on the Missouri bottoms Crows often have destroyed two or three successive seedings of corn, but only in fields near timber.

Marietta, Ga.—The damage is sometimes excessive, depending largely on location of field.

Louisville, Ky.—The damage has been greatly exaggerated. Formerly it was sometimes great, but it is many years since Crows have done any harm in my neighborhood by pulling up corn. They find other food in abundance and have forgotten their old habits.

South Frankfort, Mich.—Injurious only in exceptional cases, and to a limited extent.

Minneapolis, Minn.—The extent of the injury is measured only by the opportunity.

Watkins, N. Y.—Farmers complain of their pulling corn in the spring as soon as it appears above ground; and corn is injured in this way sometimes so that it harvests one-eighth to one-fourth less than if it had not been touched. But not one farmer in twenty is injured as much as stated.

Mount Vernon, Ohio.—Have known them to be quite troublesome in pulling corn when it is two or three inches high, * * * but their attacks appear to be only periodical, perhaps many years apart.

Berwick, Pa.—The damage is sufficient sometimes to compel the farmer to replant, yet the amount of injury done is not often of much account. There are exceptional cases when fields planted near their resorts have suffered considerably.

A careful examination of all the available evidence bearing on this question brings out one or two points which are doubtless familiar to many farmers, but may be new to some. Other things being equal, the greatest damage is done where Crows are most abundant; and fields nearest their nests are much more likely to be plundered than those at a distance from woods. Nevertheless, in the latter case, if the fields are also at a distance from the farm-house and are not specially protected, they may suffer more than other fields which, although near the woods, are so situated as to be easily watched from the house. It is of the utmost importance, moreover, that the Crows be prevented from *beginning* to take corn from a field; for after visiting it once they are far more likely to come again, and there is abundant evidence that after a Crow has once formed the habit of corn-pulling it is almost impossible to prevent his gratifying his taste as long as he lives.

Sometimes the shooting of one or more of the thieves on their first visit to a corn-field will effectually prevent further depredations, but this is not always the case. Scarecrows, windmills, glittering tin, twine, and even the swinging bodies of their slain comrades, do not have the desired effect at all times. Other methods have been tried with more or less success, but all the successful plans involve the expenditure of considerable time, and often a little money as well.

The most generally successful plan of which we have any knowledge consists in coating the corn with tar of some kind before planting, in which case Crows are said to let it entirely alone. Mr. J. V. Henry Nott, of Kingston, N. Y., thus speaks of this method:

I have used for years coal-tar on my seed corn to keep the Crow and chipmunk from eating it. I think it better than scarecrows, as it allows the Crow to roam over the field and pick up insects. I soak the seed over night, and after draining off the water thoroughly stir the tar through it by dipping a small stick in the tar, and then vigorously stirring the seed with it until all is a brown color, after which I stir in plaster until the seed looks like sugar-coated pills. The only objection is that a planter can not be used.

Essentially the same method is used for corn and other grain throughout a considerable part of the Eastern and Southern States, and apparently with good success. Wood ashes, or even dry earth, may be used in place of the plaster, the only use of which is to prevent the grains from sticking together or to the hand of the planter. On many of the rice plantations of South Carolina and Louisiana the same method is resorted to to prevent blackbirds or "rice-birds" from eating the newly sown grain or pulling up the young shoots. It is said that the young shoots from grain thus "tarred" have a strong taste and smell of the tar even until they are several inches high and beyond danger of being uprooted by birds. However this may be, the grain itself is certainly unpalatable to Crows, and they seem to be satisfied after a few trials that corn of that kind is not worth pulling.

Mrs. Margaret Musick, of Mount Carmel, Mo., states that "young corn may be effectually protected by feeding the birds boiled corn or soaked corn, sown broadcast, two quarts to ten acres."

Edward Paschall, of Doylestown, Pa., mentions a similar method used at that place. He says:

Samuel Hart, of this place, a farmer, protects his corn-field every spring against Crows by simply scattering some loose grain every day around his entire field of ten acres; every other day will answer, provided the supply is not exhausted. This method has been practiced with entire success for many years, and though Crows are very numerous, no corn is pulled up. The entire cost, as estimated by Mr. Hart, is the time required and a total of half a bushel of corn.

In some places grain soaked in strychnine has been used to kill Crows, but although they doubtless can be exterminated in this way, the method is attended with some danger to other birds, and to domesticated fowls, while it is not altogether certain that the entire extermination of Crows is desirable at the present time. They are known to do some good—how much is not definitely known, but in another part of this report will be found a summary of the evidence on this point.

It may be remarked here that many farmers as well as other observers contend that the Crow when pulling up corn is only searching for cut-worms or other injurious insects, and in support of this assertion it has been claimed repeatedly that the old Crows do not eat the corn so pulled, nor carry it to their young. This question

will be fully treated under the head of Insect Food of the Crow, and it need only be remarked here that, while Crows undoubtedly eat many cut-worms and other insects, there is very little evidence that they pull young corn for any other purpose than to get the kernel at the root.

The depredations of the common Crow do not cease, except temporarily, when the young plants are too well rooted to be pulled with ease. After the ears are formed and the kernels well filled out the Crow again visits the corn-fields, and sometimes does serious damage. At that time the young are as large as their parents, several families are commonly associated in a flock, and such a party is capable of a large amount of mischief in a comparatively short time. About fifty complaints of injury to "green corn," "corn in the milk," "roasting ears," and "ripening corn," have been received, and from these we select a few samples.

From U. G. Gordon, Barry, Ohio:

The Crows ate corn here while it was in the milk last August and September (1886), some farmers hereabouts losing one-fourth of their crop. They came in flocks, thousands at a time.

From S. T. Kimball, Ellington, Conn.:

It is in the fall that the Crow does his mischief by taking corn in the milk and after it is cut. Last year I judge that I could have picked up a bushel of cobs per acre at the time of cutting. The damage was done wholly by Crows.

From Edwin B. Clark, Waxahachie, Tex.:

Crows eat corn while in the "roasting-ear" stage, that is, before it has hardened or matured, say about four months after planting. Their depredations, however, are confined to corn-fields along creeks or branches of streams where they rear their young in trees. The corn hardens so quickly that the Crows' work is of short duration, hence the destruction is not considered alarming.

From George C. Bunsen, West Belleville, Ill.:

It not only picks up the young corn but when the corn is in the milk it is after it again, tearing open the husk and feeding on the kernels freely. It comes into the corn-fields for this purpose in great swarms and does a great deal of mischief.

From N. W. Wright, Farmland, Ind.:

During the last few years the Crows in this section of the country flock together in the fall (about August), and when the corn is soft they tear the husk from the ears and eat the grain, greatly damaging the crop. This fall I have passed fields adjoining woods where nearly every ear was so mangled as to be seriously injured.

From Charles E. Ingalls, East Templeton, Mass.:

The Crow has been known to eat corn when "in the milk." My attention has lately been called to several instances of this kind where the corn-stalks were pulled down, the ears stripped on one side, and the kernels pecked out. This mischief was charged to 'coons until I showed the real culprit.

Crows also eat considerable quantities of ripened corn, but they do not appear to like it as well as when in the milk. Mr. W. B. Hall, of Wakeman, Ohio, states that tame Crows which he has kept at various times "would not eat dry grain, but were very fond of green corn when husked."

From upward of seventy reports of damage to ripened corn a few are selected.

From Hugh N. Starnes, Marietta, Ga.:

In the fall some damage is done to corn in the ear, after ripening and before gathering, but the damage is inconsiderable.

From D. C. Shely, Nicholasville, Ky.:

I have known Crows to destroy one-fourth to one-half of a corn crop when left out in winter and everything else was snowed under. There is no necessity for any such loss if the farmer would secure his crop in reasonable time.

From H. A. Koch, College Hill, Ohio:

Crows frequent the corn-fields in such numbers that their depredations seriously affect the crop, especially when the corn is left standing in shock long.

From H. C. Griswold, Watkins, N. Y.:

At the present time (September 30, 1885), two or three hundred Crows are feeding upon standing corn.

INJURY TO OTHER CEREALS THAN CORN.

Although the Crow attacks and injures other grains than corn its depredations on these crops are far less general and serious. About fifty reports of such injury have been received, the losses complained of relating to wheat, rye, oats, barley, and rice. As with corn, the greatest damage is done by pulling up the sprouting grain, but more or less is eaten while ripening, or even when hard. A few samples of the evidence are appended.

From F. H. Holmes, Rio Vista, Cal.:

The Crow does some damage in the grain sections around Rio Vista to wheat and barley, just after sowing and until it is well sprouted.

From W. E. Dingman, Newton, Iowa:

In some instances it is known to pull up and eat wheat and rye when two or three inches in height. The damage has not been very extensive in either case.

From Asher Tyler, Forest Grove, Oregon:

The Crows congregate here in large flocks, but are only destructive to new-sown wheat.

DAMAGE TO OTHER CROPS.

About a dozen reports, nearly all from New England and Canada, mention the Crow as destructive to potatoes, the worst mischief being done by pulling up the young plants in order to get the partly decayed pieces planted as "seed." Occasionally sweet potatoes and beans are pulled up in the same way, and in some of the Southern States the Crow digs up pea-nuts both as seed and when ripening, sometimes causing considerable loss. The following notes from correspondents illustrate this class of injuries:

From S. F. Cheney, Grand Manan, New Brunswick:

The Crow will take the potato seed out of the hill and pull up the potatoes when nearly ready to hoe.

From Manly Hardy, Brewer, Me.:

I have known newly planted potatoes to be destroyed by the acre. Have only known Crows to attack potatoes within a few years (1885).

From Charles F. Goodhue, Webster, N. H.:

Crows are very troublesome some years by pulling corn and digging up newly planted potatoes, destroying both just as they appear above ground. The damage done to corn and potatoes varies from a few hills to nearly two acres. Sometimes nearly the whole crop is destroyed.

From Walter Hoxie, Frogmore, S. C.:

The Crow destroys seed corn and rice invariably, unless tarred. It is yet more destructive to pea-nuts and sweet potatoes.

From J. W. Johnson, Meriwether, S. C.:

Crows are very destructive to pindars [pea-nuts], scratching them up about the time they mature.

From John M. Richardson, Daingerfield, Tex.:

I have known the Crow, assembling in immense flocks, to do great harm to the pindar [pea-nut] crop in South Carolina. As the nuts approached maturity the fields had to be guarded by men and boys with guns from early dawn to late dusk.

In some parts of the country the Crow seems to have acquired a taste for water-melons, doing no little damage to this important crop. Mr. H. E. VanDeman states that at one time, on his farm at Genoa, Kans., he was obliged to cover some of his water-melons with grass, weeds, etc., in order to protect them from a family of Crows which otherwise would have ruined them all. They began to "plug" the melons as soon as they were nearly ripe, going from one to another until they found one which suited them, spoiling many which they did not eat. Reports of similar damage have been received from Georgia and South Carolina, one planter complaining that his melons are attacked before they are half grown, and another estimating his loss from the same cause at 10 per cent. of the crop.

Occasionally Crows do much damage to ripening fruit, but they generally find an abundant supply of wild fruits, and do not care to run the risk of a near approach to the garden unless the display is particularly tempting.

Virgil Green, of Bullville, N. Y., says:

I have known Crows to strip a large cherry tree of its fruit when the cherries were beginning to ripen.

George Donaldson, of Gilbertsville, N. Y., says:

The Crow eats strawberries, blackberries, raspberries, and cherries.

Half a dozen other complaints of damage to cherries have been received. Apples are more rarely attacked, but a few reports of injury to this fruit are at hand, of which the following is one:

From E. M. Wilson, Belfast, N. Y.:

Crows sometimes seem to eat apples on the trees in the fall of the year, damaging the largest and finest fruit. However, I am not positive in this matter, the evidence being circumstantial, so to speak. Crows were seen in apple trees, and the fruit was now and then pecked and eaten on one side, plainly by a bird with a large beak. My father tells me that he has seen Crows eating apples in an orchard.

From the fact that Crows feed largely on wild grapes, it seems a little strange that they do not visit the vineyard more frequently, but as yet very few complaints on this score have been received. One vineyard of several acres lying just outside the limits of the city of Washington, D. C., has suffered considerable loss for several years from the frequent attacks of Crows. One of the assistant ornithologists visited it in September, 1886, and again in the same month in 1888, and found abundant evidence that the owner did not exaggerate when he stated his loss to be at least one-fourth of the crop. Not only were Crows frequently seen eating the grapes, but two which were shot during the first visit had grape seeds in their stomachs.

OTHER VEGETABLE FOOD OF THE CROW.

In addition to the fruits and vegetables already mentioned as forming a part of the Crow's food, there are very many wild fruits, berries, seeds, and nuts, on which the Crow feeds largely at times, but the consumption of which is of little account to the farmer under any circumstances.

The vegetable matter contained in the eighty-six stomachs examined was as follows:

Vegetable Contents of Stomachs.	No. of stomachs in which found.
Kernels of corn	35
oats	3
wheat	2
Remains of acorns or chestnuts	26
cherries, cultivated varieties	8
wild cherries	3
berries not identified	4
haw berries (*Cratægus*)	1
Fruit pulp, not identified	4
Seeds of grape	7
blackberries or raspberries	5
pumpkin	2
cucumber or musk-melon	1
beach plum	2
Virginia creeper (*Ampelopsis*)	2
dogwood or cornel (*Cornus*)	4
bayberry (*Myrica*)	3
common (harmless) sumachs (*Rhus*)	17
poison sumach and poison ivy (*Rhus*)	19
juniper or red cedar	1
bind-weed (*Polygonum*)	2
wild rice (*Zizania*)	1
Unidentified seeds	10
Sea-weed	4
Moss	1

The Crow is known also to eat the berries of the wintergreen, poke-weed, elder, smilax, and hackberry; and doubtless it also feeds upon numerous other berries and seeds.

During autumn, and especially in the districts where grain is not readily obtainable, a favorite food of the Crow is acorns, beech-nuts, or chestnuts, immense quantities of which are consumed. It may be mentioned incidentally also that in parts of Louisiana and Texas, and probably in other States, the Crow injures the pecan crop to a considerable extent.

THE DISTRIBUTION OF NOXIOUS SEEDS.

An interesting fact, which has come to light recently through the examination of Crow stomachs, is the discovery that the berries of poison sumach (*Rhus venenata*) and poison ivy (*Rhus toxicodendron*) are eaten in large numbers by the Crow.

The poison ivy (also called poison vine, poison oak, mercury or mercury vine, etc.), is too well known to need any description. The poison sumach (also called swamp sumach, poison elder, poison dog-

wood, etc.) is a shrub or small tree, confined mainly to swamps and wet places, and less generally known than the ivy, though its poison is much more powerful. Both species bear straggling bunches of greenish-white, waxy berries, which cling tightly to the stems through the entire winter and thus are readily obtained by Crows even when the ground is deeply covered with snow. Each berry contains a single large seed or stone surrounded by a small amount of wax-like pulp, which appears to contain considerable nutritious matter.

Stomachs of Crows taken in every month from September to March, and in different localities from Massachusetts to Florida, were found to contain these seeds, sometimes in large numbers. In one case one hundred and fifty-three seeds of poison ivy were found in a single stomach; in several cases the number was more than one hundred, and the average in nineteen stomachs exceeded fifty.

At a large Crow-roost on the Virginia side of the Potomac, near Washington, the droppings of the Crows are literally full of these seeds, usually accompanied by many seeds of the harmless (red-berried) sumachs, and a still smaller number of those of the flowering dogwood (*Cornus florida*) and the sour gum (*Nyssa*). The same is true of the large roost near Baltimore, Md., whence Mr. C. L. Edwards, of the Johns Hopkins University, sent to the Department seeds of all the above species more than a year ago. The seeds of poison ivy and poison sumach had been found previously in Crow stomachs collected near Washington, but for lack of a good reference collection of seeds they remained unrecognized until December, 1888, when they were identified by the writer.

In order to give some idea of the number of these seeds consumed by the Crow it may be stated that a single pound of the dried excrement taken from the roost in the national cemetery at Arlington, February 8, 1889, contained by actual count 1,041 seeds of poison ivy and 341 seeds of poison sumach, in addition to 3,271 seeds of other sumachs, 95 seeds of Virginia juniper, 10 seeds of flowering dogwood, and 6 seeds of sour gum. The material, which covered about four square feet, was taken at random from above the layer of leaves, and represents the average deposit on the roost. As the roost covers upward of fifteen acres, some idea may be formed of the number of these seeds deposited there.

It is a well-known fact that the germination of many kinds of seeds is hastened by their passage through the digestive organs of birds and other animals, and hence it was believed at once that the Crow was aiding in the distribution of these poisonous plants. In order to place the matter beyond question, however, seeds taken from the Arlington roost were tested in several ways, and not only was their vitality found to be unimpaired, but they were found to germinate more quickly than seeds taken from the vine. Of one hundred seeds of *Rhus venenata* from the roost, moistened and kept warm, ten sprouted within forty-eight hours, and twenty more within the next five days. One hundred and fifty seeds of the same kind and from the same source were planted in a flower-pot in the greenhouse, and at the end of fourteen days one hundred and thirty of them had become vigorous seedlings from one to two inches high, and several more were breaking the ground. Similar results were obtained with seeds of *Rhus toxicodendron* from the roost, while seeds taken from the vine had not sprouted at the end of fourteen days. Thus it becomes certain that these seeds are improved rather than impaired by their passage through the digestive organs of the Crow, and this bird

therefore is doing incalculable harm by sowing broadcast the seeds of a poisonous vine and a more poisonous shrub, both of which unfortunately are far too abundant already.

THE CROW AS A DESTROYER OF THE EGGS AND YOUNG OF POULTRY AND WILD BIRDS.

More than three hundred and fifty of our correspondents have contributed notes relating to the Crow as a robber of the nests of domesticated fowls and wild birds. About seventy of these state simply that "no damage of this kind has been observed," but with this exception the evidence is almost wholly unfavorable to the Crow. Two hundred and seventy-eight observers state distinctly that they know of more or less mischief of this kind committed by Crows. One hundred and forty-seven have personal knowledge of its carrying off young chickens, and one hundred and seventy-four report damage to domesticated fowls. There are twenty-five complaints of injury to the eggs and young of turkeys, and about a dozen instances of similar damage to ducks and geese.

Rather more than ten per cent. of the reports on domesticated fowls state that the damage is slight or occasional, but on the other hand upward of fifty observers report frequent and serious depredations, many of them stating that the Crows do much more damage than hawks. It is significant that out of more than three hundred and fifty replies to the question covering the subject of damage to domesticated fowls and wild birds only five are positively favorable to the Crow. Seventy others are negatively favorable in that they report no injury observed, without, however, giving any indication of the extent of the opportunities for observation. The reports of damage come from all parts of the United States and Canada where Crows are found, and as a rule the notes are clear and exact.

As one result of all the information thus far collected it may be stated that the Common Crow is a serious enemy of poultry, all the more dangerous because so often unsuspected, and because of its remarkable cunning and stealth. It is also a skilful and inveterate robber of the nests and eggs of wild birds.

The entire evidence submitted on this subject is well worth reading, but lack of space forbids the insertion of more than a few examples under each of two heads.

DESTRUCTION OF THE EGGS AND YOUNG OF POULTRY.

More than one-third of all the reports relating to damage to poultry specify frequent or serious loss. It appears from these notes that not only does the Crow rob the hens, ducks, and turkeys which steal their nests in the brush, woods, or meadows, away from the farm-yard, but it frequently comes within a few steps of the house or barn, destroying all nests not absolutely inaccessible to it or snatching up the downy young about the very doors. Usually such visits are made very early in the morning, or at times when no one is at hand to prevent the theft, but frequently the robber becomes emboldened by success and makes his visits in the middle of the day and with apparent disregard of all danger. Moreover, as in the case of some hawks and dogs, certain individuals become particularly addicted to chicken stealing, and return day after day to the same place, seldom failing to secure a victim at each visit.

The following notes from different parts of the country will serve to illustrate the Crow's methods in relation to eggs and chickens:

From Owen Durfee, Fall River, Mass.:

May 5 [1888], while walking by a farm-house near the city, I saw a Crow sail over the house and finally settle down on a stone wall about 100 feet from the house, and begin watching the young chickens running about in the lot and through the wall under him. One of the chickens ran under him, and after eyeing it a moment, he turned to the next one, which was perhaps a week or ten days old. When this one was about six feet from him, he dropped down over it and struck at it two or three times with his beak. Then he acted as though about to eat it on the spot, but a young rooster running at him, he picked up the chicken and carried it off still squawking in his beak.

From William H. Lewis, Pawtucket, R. I.:

I have known the Common Crow to take chicks when they were from one to six weeks old. I know of a case where twenty have been lost this season.

From H. Nehrling, Freistatt, Mo.:

I have frequently observed Crows stealing the eggs from my poultry-yard. They do this very slyly and quietly. As soon as the eggs are hatched they carry off young chickens whenever they can get them. With the exception of Cooper's Hawk I do not know such a bold robber as the Crow. One day in April one of these birds perched on the fence, only a few steps from my house. An old hen with about a dozen chickens which were only a few days old was in my barn-yard. Suddenly the Crow swooped down, caught a chicken with its bill, and went off, flying away near the ground. In a few weeks the Crows carried off about twenty chickens, which varied in age from one day to four weeks.

From H. R. Landis, Landis Valley, Pa.:

When the young are hatched the Crows are very bold, coming up to buildings, and in one case that came under my notice they took from one to four chickens each morning, nearly annihilating a brood of about one hundred.

From J. W. Van Kirk, Milton, Pa.:

I have seen Crows catch young chickens, and frequently have seen them carrying off eggs of both the domestic fowl and wild birds. We have had on different occasions whole nests of sitting turkeys and chickens robbed by them. In some cases the eggs were taken from under the hens while on their nests.

From David A. Vail, Atlanticville, N. Y.:

On several occasions I have known the Crow to catch and carry off young chickens from the hen-yard. I have known him to return regularly every day for a chicken, and get it, too, unless some one was on the watch to frighten him away.

From J. V. Henry Knott, Kingston, N. Y.:

I have seen the Common Crow eat eggs, and have caught him by baiting a steel-trap with an egg. The man in charge of the gas-works at Saugerties told me this spring that he had to cover his chicken-yard with wire to save the chickens from the Crows, and that he saw them catch the chickens repeatedly.

From W. K. Nelson, Augusta, Ga.:

The Common Crow will steal eggs; I have poisoned the eggs and killed the Crow.

From Frank B. Hancock, Casky, Ky.:

The Common Crow undoubtedly catches young chickens and steals eggs. They have caused me more trouble in that respect than hawks. My home is situated on the south side of a woodland. A colony of Crows located in that woodland in 1870. This spring (1885) I have watched them carefully, and have seen them steal chickens before they were past the *downy stage* and carry them away to their young. I have one Crow family charged with $25 worth of nice chicks stolen in April and May, 1885.

Occasionally the Crow attacks full-grown fowls, as evidenced by the following notes:

From George A. Boardman, Calais, Me.:

The Common Crow has been observed to catch young chickens and steal eggs, and also full-grown hens.

From Erney Tulley, Penza, Ohio:

I have never known of Crows killing young chickens, but I once surprised two Crows fighting an old hen in a little bunch of willows, and have no doubt that they would have killed her in time had I not interfered.

In all probability these were cases in which the hens were weak and partially disabled, or else the Crows were driven to desperation by hunger, and took advantage of unusually favorable circumstances.

The following reports show that the Crow uses the same methods on turkeys, ducks, and geese as on chickens:

From W. V. Hardy, Holman Station, Ind.:

In the spring of 1885 the Crows visited our turkeys' nests every day, also geese, nests, doing a great amount of damage.

From F. H. Holmes, Rio Vista, Cal.:

On the Lower Sacramento River, I knew of one Crow which killed no less than thirteen young ducks in the space of three days during a cold, rainy spell in February, though otherwise I never knew it to do any damage to young poultry.

From Fred. S. Odle, Lapeer, Mich.:

Two years ago in this locality I noticed an instance where Crows stole eggs from a duck's nest, and carried them nearly a quarter of a mile to their own nest. I found an egg on a stump about half way, with only two claw marks in it. The nest of the Crow was in a small pine and had young in it at the time.

From Gideon Mabbett, Rodney, Miss.:

I have seen Crows come to the house and carry off nearly the whole setting of young ducks in one day.

From John A. Weems, Flora, Ala.:

The Common Crow is the worst egg thief I ever had to contend with. I have never known Crows to catch young chickens, but they have destroyed at least one hundred turkey eggs for me during the last spring and early summer.

From D. E. Pannepacker, Chalfont, Pa.:

On May 15, 1888, while I was slowly making my way through the forest, I noticed a Crow some 150 yards ahead of me. I thought his peculiar antics meant something, and upon coming closer to him I noticed that he was teasing a setting turkey. I found too that he was not alone, but was assisted by his mate. He ran up to the turkey, seized hold of its tail feathers, and then when the turkey rose to defend herself against his impudence, his mate ran up in front of the turkey, thrust his beak through an egg and flew off to his nest. In about fifteen minutes they returned, but by some means or other became aware of my presence and flew away, nor did they return at any time while I watched them, though they managed eventually to steal eleven out of thirteen of the eggs.

From Thomas W. Florer, Waxahachie, Tex.:

A farmer's man here had a brood of some fifty turkeys, and a Crow having a nest of young in a neighboring wood commenced appropriating the young turkeys until the brood was reduced to fifteen. These were kept close until as large as quails and there was no further molestation.

In connection with this habit of the Crow the most favorable report received came from Mr. J. M. Nipp, of Bolton, Mo., who says:

Individual members of the Crow family, like those of the human family, are capable of learning bad habits.

Less than one Crow in twenty learns to steal eggs or young chickens, and they are only bad when feeding their young. Two years ago last spring one got to tak-

ing chickens from our yard. I watched him fly to the nest, and next morning when the sun was an hour high I killed the young Crows to see what they had been fed on for breakfast. They had been fed one chicken, eight mice, and twenty-two grasshoppers. It was easy to count the chicken's feet, mice's tails, and grasshoppers' heads when the five pouches were opened.

DESTRUCTION OF EGGS AND YOUNG OF WILD BIRDS.

No observant person will deny that the Crow does serious damage to the eggs and young of wild birds. The instances of such depredation which have come within the knowledge of most farmers or other persons living in the country are far too numerous to leave a shadow of doubt on this score in any unprejudiced mind.

Yet for every instance of such robbery witnessed by man thousands must take place without his knowledge. Persecution by Crows is doubtless a very large factor among the influences which cause so many birds to crowd about human habitations during the nesting season, and yet the relentless Crow follows them even to the eaves and window-sills of houses, taking their eggs and young in spite of every precaution.

The evidence on this point, contributed by our observers during the past few years, is replete with accounts of such forays, and the only wonder is that robins, thrushes, blackbirds, and many other species continue to rear any young at all. The reports on this subject number one hundred and fifty or more, and contain minute descriptions of the destruction by Crows of the eggs or young of more than twenty-five species of wild birds. The list includes the robin, wood thrush and other thrushes; brown thrasher, wrens, English sparrows and other sparrows, blackbirds of several species, Baltimore and Bullock's orioles, woodpeckers, swallows, kingbirds, waxwing, warblers, bluejay, Carolina dove, quail, prairie chicken, woodcock, night herons and other waders, wild ducks, and sea-gulls. In addition to these specific statements, very many observers state that all kinds of small birds suffer from Crows, while others say that it kills "many kinds" or "all kinds which can be obtained."

Naturally the robin is one of the most frequent sufferers, and perhaps its losses are more likely to be noticed than those of less familiar birds. The following reports indicate something of the nature and extent of the inroads upon this species:

From Prof. F. E. L. Beal, Lunenburgh, Mass.:

I have known the Crow to rob the nest of a robin of its eggs on several occasions, always at the first peep of light. In one instance the nest robbed was within six feet of the open window of a chamber where I slept.

From Charles F. Goodhue, Webster, N. H.:

The Crow has been known to rob every robin's nest in a good-sized apple orchard, and to come within eight rods of the house and carry off four young robins in the course of one day.

From J. W. Van Kirk, Milton, Pa.:

Last spring (1886) out of ten robins' nests around our building, nine were robbed of eggs by the Crow. One of the nests was not over 20 yards from the house. The robin lays from three to five eggs, and you can safely say that at least forty robins were thus destroyed inside of eight acres of ground.

From Dr. A. K. Fisher, Sing Sing, N. Y.:

A great number of nests of the robin, wood thrush, and in fact many other birds, are robbed of their eggs, and I have often observed Crows flying away with young birds in their bills, followed by the outraged parents.

In examining the contents of Crows' stomachs in spring, I have detected the presence of birds' eggs in a number of cases.

Such instances might be given by the score, but we have space only for enough samples to show that we have not overestimated the extent of the mischief or the number of species which suffer.

From C. S. Paine, East Bethel, Vt.:

Crows come into our shade trees early in the morning and take the eggs and young of the oriole and robin: I think that over half of the nests of our small birds are destroyed by them.

From William Proud, Chico, Cal.:

Crows destroy great numbers of eggs and young of small birds. The hanging nest of the oriole (*Icterus bullocki*) seems to be a favorite mark for them.

From D. Y. Overton, Burlington, Iowa:

The Common Crow, especially at the East, is an inveterate robber of birds' nests, and also destroys their young. I have seen him at the nests of the robin with the eggs in his mouth; and have seen him with young bluejays in his beak as he took them from the nest.

From Dr. Frank H. Braymer, West Pawlet, Vt.:

The Crow eats the eggs and young of other birds, particularly of the robin, waxwing, thrush, etc.

From Charles A. Davis, Burlington, Vt.:

I have seen Crows catch and carry to their nests eight or ten young bank swallows which were feathered out.

From Manly Hardy, Brewer, Me.:

It destroys the eggs and young of all birds whose nests it can reach. I have seen night-herons' eggs thus destroyed by the hundred.

From Samuel N. Rhoades, Haddonfield, N. J.:

The Crow steals eggs and young birds from the purple grackle, red-winged blackbird, robin, kingbird, Carolina dove, quail, and woodcock. It also destroys the eggs of several species of herons.

The last report and the two following may interest sportsmen, as they illustrate a very common habit of the Crow, and one which will account in a large measure for the decrease of game birds in some parts of the country.

Prof. D. E. Lantz, of Manhattan, Kans., writes:

I have not known the Crow to trouble the poultry-yard in Kansas, but it is a noted robber of the eggs of quail and pinnated grouse.

Dr. A. B. MacCrea, of Berwick, Pa., writes:

A friend was mowing in the meadow this summer (1885) and uncovered a quail's nest containing some twenty eggs. He concluded to place them under a hen and went to the barn for a basket; when he returned a Crow was finishing his dinner on the last egg.

In all the dark history of the Crow's relations to other birds there is nothing which can be fairly called a bright spot, and only here and there a record is found which serves to render the page a little less gloomy. One of these grains of comfort is found in the fact that in its wholesale attacks on other birds a few species suffer which are scarcely better than itself. The bluejay and the purple grackle are known to destroy the eggs and young of smaller birds, and their own nests are frequently pillaged by the more powerful Crow. Under favorable circumstances Crows are known to destroy the eggs and young of the English sparrow, and they have done good service in this way about the Smithsonian Institution, in Washington, D. C.,

where it is no uncommon sight during the summer to see a Crow (most often perhaps the Fish Crow) feeding on the young of these birds.

INSECT FOOD OF THE CROW.

In attempting to study the insect food of the Crow, two different questions present themselves at the outset. These are: (*a*) How many insects does the Crow eat? and (*b*) What kinds of insects does it eat? The first question was answered in a general way more than half a century ago, and there is no reason now to deny the oft-repeated statement that the Crow feeds largely on insects. The second question, however, is not only much more important but much less easily answered; for not all insects are injurious, and comparatively few persons can discriminate between the useful and harmful, especially when watching them from a distance or examining those which have been crushed and swallowed by a bird.

While, therefore, the field-notes of casual observers may help materially to answer the question as to the extent to which the Crow feeds on insects in general, they can seldom be relied upon for an accurate knowledge of the insect species destroyed. As already stated, this latter question must be answered mainly by the critical study of the stomach-contents of large numbers of Crows. Nevertheless, the accumulated observations of years as to the Crow's manner of feeding, together with notes on places most visited at certain times, and the insects most abundant in those places at such times, must not be disregarded, many such observations being of the greatest practical value.

In the course of the present investigation on the Crow, hundreds of notes on its insect-eating habits have been received from correspondents, and in many cases the observations are of great interest and value. Not a few of these notes relate to observations made under peculiarly favorable circumstances, and though we can not feel perfectly sure of the correct identification, for example, of the Hessian fly and army-worm, we see no reason to doubt the statements of any farmer as to grasshoppers and potato beetles, or even cut-worms and "white grubs." It is true they may not know the scientific names of the particular species of grasshopper or grub noted, but the observation, though *less* valuable on this account, is still of definite worth. A few observers have examined stomachs of Crows occasionally, and their testimony in regard to the insects found therein therefore possess unusual value, but the larger number by far base their statements entirely on field observations.

A few farmers contend that the Crow rarely or never eats insects of any kind, while others simply state that they have never seen it do so, and express a favorable or unfavorable opinion as to the probability of such a habit. These, however, are individual exceptions, the great majority of observers stating emphatically that the Crow does eat insects, and that he eats many; in fact, the unanimity of opinion on this point is rather surprising, and much of the most favorable testimony comes from men who are most severe on the Crow as regards its other habits.

In this connection, the evidence furnished by the stomachs examined in the Division during the past year is interesting. The insects contained in these stomachs have been submitted to the Entomologist of the Department, and a summary of the results of his examination will be found in another place; but while examining the other

components of the food it was easy to separate the insect material from the rest, and to estimate the proportion which it formed of the entire food.

The following table, showing the amount of insect food in the stomachs examined, contains several points of interest:

Table showing the amount of insect food in the stomachs of eighty-six Crows (Corvus americanus), arranged by months.

Month.	No. of stomachs examined.	No. of stomachs containing insects.	Percentage of stomachs containing insects.	Average percentage of insect food in stomachs containing it.	Average percentage of insect food in all stomachs examined.
January	14	4	28.6	7.	2.
February	6	1	16.7	1.	.17
March	1	1	100.	1.	1.
April	0	....	....	....	....
May	3	3	100.	76.	76.
June	3	3	100.	14.7	14.7
July	16	14	87.5	32.6	28.5
August	0	....	....	....	....
September	7	6	85.7	33.	28.3
October	13	10	76.9	12.8	9.8
November	3	3	100.	17.3	17.3
December	20	18	90.	5.9	5.4
	86	63	73.2	19.7	14.5

It appears from the above table that sixty-three of the eighty-six stomachs of the Common Crow which were examined, or more than 73 per cent., contained some insect food, the average amount in each of the sixty-three stomachs being nearly 20 per cent., or one-fifth of the entire food. Fourteen and one-half per cent. of all the food contained in the whole eighty-six stomachs consisted of insects, and this in spite of the fact that two-thirds of these stomachs were from birds taken during the colder half of the year, namely, between October 1 and April 1.

At first sight it seems still more remarkable that 90 per cent. of the stomachs taken in December contained some insect food, while but 87½ per cent. of those taken in July contained insects. Those taken in July, however, contained in the aggregate more than five times as much food of this kind as those taken in December.

Again, of the fourteen stomachs taken in January, but four contained insect remains, as against eighteen out of twenty taken in December. By consulting the detailed results of the examination, however, the reason is evident; for ten of the January birds were taken at East Hartford, Conn., when the ground was mostly covered with snow, while most of the December birds were taken near Washington, D. C., when the ground was mostly bare.

These few facts show how essential is the examination of large numbers of stomachs in order to secure accurate results, but nevertheless it is impossible to avoid the conclusion that Crows eat insects freely at all seasons of the year, and that the main reason why they do not eat as many in cold weather as in warm is simply because they are not to be had then. These conclusions receive additional confirmation from the reports of observers, very many of whom state that the Crow feeds on insects at all times of the year, but is especially destructive to them when they are exceptionally abundant.

Turning now to the reports of observers as to the *kinds* of insects eaten, we find additional testimony favorable to the Crow.

The following list gives the names of all insects on which the Crow is said to feed, together with the number of observers reporting each kind:

Names.	No. of reports.	Names.	No. of reports.
Insects of all kinds	11	Army-worms	3
Insects, kind not specified	54	Tobacco-worms	2
Grasshoppers	80	Earth-worms	7
Crickets	8	Worms, kind not specified	10
"Locusts"	4	Ants	2
Seventeen-year cicada	2	"Bugs," kind not specified	6
"White grubs"	32	Tent caterpillar	1
Grubs, kind not specified	49	Apple-tree worm	1
Cut-worms	44	Canker-worm	1
May beetles	5	Corn-worm	1
"June bugs"	2	Bud-worm	1
Potato beetles	6	"Millers"	1
Beetles, kind not specified	13	Hessian fly	1
Caterpillars	7	Cocoons	2
Wire-worms	6	Crysalids	2

A glance at the above list shows that certain groups of insects are reported by large numbers of observers, and it is interesting to note that in almost every case the insects so reported are decidedly injurious. Thus grubs and "white grubs" aggregate eighty-one reports, cut-worms are mentioned in forty-four, and grasshoppers in eighty.

Among the numerous reports which mention a considerable variety of insects the following may be instanced:

From William Proud, Chico, Cal.:

It is a great devourer of grubs, caterpillars, chrysalises, etc.; including wire-worms, larvæ of cockchafer, beetles, army-worms, grasshoppers, and any other noxious vermin that falls in the way.

From Marcus S. Crane, Caldwell, N. J.:

It frequently visits newly plowed fields for grubs and worms, and I think it also searches for cut-worms in the corn-fields. I have noticed Crows feeding in a meadow the morning after it was mowed, and think they destroy a great many grasshoppers, bugs, and caterpillars.

From Elisha Slade, Somerset, Mass.:

Crows feed upon injurious insects at all times of the year, and very sensibly reduce the number of cut-worms, larvæ of the May bug, and the bugs themselves, wire-worms, and various caterpillars which infest the field, orchard, pasture, and meadow. From more than a quarter of a century's observation, I consider the Crow of more benefit to the agriculturist in its destruction of insects than injury to the grain, eggs, and chickens; I am a farmer myself and have had several disastrous visits from the Crows.

From Dr. Morris Gibbs, Kalamazoo, Mich.:

The Crow has been observed to feed upon injurious insects, such as orthoptera, coleopterous larvæ, and chrysalids of lepidoptera, especially *Cecropia* cocoons.

From Dr. Hiram A. Cutting, Lunenburgh, Vt.:

It has been observed to eat caterpillars, potato beetles, and grasshoppers; also white grubs and cut-worms.

Very many farmers must have noticed the habit which the Crow has, in common with various blackbirds and some other species, of

following the plow, especially in spring or early summer, or of frequenting recently plowed fields. The Crow, under these circumstances, is generally credited with destroying large numbers of grubs and other insects, and there can be little question that this reputation is fully deserved.

The following notes, selected almost at random from a large number, will give a fair idea of the evidence on this point:

From E. E. Mason, Accotink, Va.:

I have had them follow me all day when I have been plowing, picking up the grub-worms. They are evidently voracious feeders and not nice as to diet, but doubtless draw the line on any of the caterpillar family. A friend of mine having shot one cut his craw open and found so many insects that he said he had killed his last Crow. I think if the Crow was less disturbed there would be less wormy roasting ears.

From F. Stephens, San Bernardino, Cal.:

The Crow is in the habit of following after the plow, picking up cut-worms, white grubs, larvæ, etc., sometimes in large quantities.

From T. Scott Fisher, East Brook, Pa.:

I watched a pair of Crows follow me day after day last spring [1886] while plowing sod, and saw one Crow pick up twenty-five to forty white grubs, cut-worms, and wire-worms at one time and then fly to the woods for an hour or so, then back and at it again.

No doubt the Crow does very much good in this way, and it is possible that the observed facts of this kind have led some people to believe, without other evidence, that Crows when pulling up corn are only in search of insects. Much interesting opinion has been contributed on this subject, together with no little good evidence. The following samples serve to illustrate the subject:

From Dr. J. R. Mathers, Buckhannon, W. Va.:

It is the opinion of many farmers that the Crow is unearthing cut-worms at the base of the corn instead of pulling up the corn, the uprooting being only an accident.

From William G. Coutan, Brackney, Pa.:

I am convinced from personal observation that the Crow pulls corn in search of grubs and worms. For where large quantities have been pulled up the grain is left intact on the sprout.

From F. R. Welsh, Philadelphia, Pa.:

On three or four occasions I have known Crows to pull up corn from two to four inches high. I do not think they eat the green top; their object seems to be to get at the seeds, which they invariably eat.

From John C. Linville, Gap, Pa.:

It feeds largely on the large white grub, the larvæ of the May beetle. When the common cut-worm is very numerous I have seen the Crow dig something out of the hill of corn and leave the corn unmolested; I think he was catching the worms.

From D. E. Pannepacker, Chalfont, Pa.:

A field of corn is adjacent to my school-house. On the 13th of May the corn was planted, and on the 22d of May I first noticed the tender shoots above the ground. The field previous to the cultivation was covered with a thick growth of sod, favorable to the existence of the grub and wire-worm. It was but natural, too, for these insects to remain, and not having the tender shoots of timothy, clover, and other grasses to satisfy their appetites, they turned their attention to the growing corn. The despised Crow here rendered most excellent service, for though he pulled up the corn, I noticed each time the well known track of the wire-worm, or the worn path of the grub.

The fact that Crows usually eat the corn from the sprouts which they pull has been spoken of in another part of this article, and is

too well known to need any demonstration. That they sometimes leave part of it untouched after pulling is also undoubtedly true, but this can hardly be used as an argument to show that it was pulled for other purposes. Where food of any kind is very abundant, the Crow probably selects the morsels which please him best, and the fact that some is left untouched only shows that he exercises his judgment in selecting his food.

An observation which has been used sometimes as an argument for the Crow is the fact that the greatest damage to corn by the Crow is in precisely the localities where the greatest injury is done by cut-worms and grubs, namely, on pasture land, mowing land, or newly cleared fields which have been broken up and planted in corn. The natural inference is that the Crows are attracted by the abundance of grubs, and incidentally do more or less mischief to the corn; but a moment's thought will show that a simpler explanation lies in the fact that such newly broken fields are generally those farthest from the farm-house, and hence less easily protected, so that the Crow seeks them in preference to the more exposed fields, and without reference to the abundance of insects there. The obvious test of guilt or innocence in such cases would be to shoot a few Crows after they have spent some time in the field and subject their stomachs to careful examination. The claim so often made that such a test would show nothing, since the soft worms would digest more rapidly than the corn, has no weight whatever, for all grubs capable of injuring corn have hard jaws or other parts which are not only indigestible, but which often are so characteristic as to make it an easy matter to identify the particular species of grub, cut-worm, or caterpillar to which they belong.

On the whole, the evidence thus far collected does not seem to give much weight to the belief that Crows eat many grubs or cut-worms in fields where corn is coming up. Nor is there any obvious reason why they should, since the grubs are more abundant in grassy fields than in cultivated ground, and, except at times when the surface has been recently disturbed, we should expect the birds to look for them anywhere rather than in corn-fields.

When edible insects of any kind are particularly abundant, birds doubtless feed more largely on them than at other times. This is well shown by the numerous published reports of the havoc wrought by birds among the seventeen-year cicada in the years of its great abundance.

The following statement by Mr. J. Percy Moore, of Philadelphia, Pa., is one of several reports showing that the Crow is no exception to this rule. Mr. Moore writes:

> When the seventeen-year cicada appeared this summer (1885) the Crow fed extensively on both its pupæ and imagoes. The young were fed to some extent on the pupæ on May 30. As they had not at this time appeared above the ground, I suppose the Crows obtained them in plowed fields.

THE CROW AN ENEMY TO GRASSHOPPERS.

Probably the most marked example of the good which Crows do by destroying insects is found in their attacks on grasshoppers, crickets, and kindred insects. Eighty observers report the Crow as feeding extensively on grasshoppers, and there can be no doubt that much good is done in this way. The following examples show something of the extent of the benefit occasionally done:

From Charles F. Goodhue, Webster, N. H.:

At this season Crows are of some benefit to the farmer, as they feed mostly on grasshoppers. To-day (August 22) a flock of nearly a hundred were observed in a pasture badly infested with grasshoppers, upon which they evidently were feeding.

From A. I. Johnson, Hydeville, Vt.:

Crows have some very good qualities, catching countless numbers of crickets and grasshoppers after the hay is cut. They can be seen at almost any time of day on the meadows catching grasshoppers. I observed one pair of old Crows this summer (1885) when I was haying, that were feeding their young almost entirely (if not quite) on grasshoppers; the old Crows would alight on the mown land within eight or ten rods of me, and after catching a hopper or two would fly to their young that were on the fence and there feed them with the hoppers.

From W. E. Saunders, London, Ontario, Canada:

Last summer (1885) I watched a flock of probably two thousand Crows catching grasshoppers.

From J. B. Underhill, Fork Union, Va.:

As to the insect diet of the adult I can not testify, having never examined the gizzards. The gizzards of two young which were taken from the nest were filled to overflowing with grasshoppers, and each contained one or two kernels of corn.

From Morris M. Green, Boonville, N. Y.:

Near Boonville I have seen the Common Crow feeding on grasshoppers during the summer months. Some fields seemed to be fairly black with the birds pursuing the grasshoppers in every direction. One day noticing a flock of Crows frequenting a particular field, I visited the place, and found that the roots of the grass had been completely eaten away, so that the sod or turf could be taken by the hand and rolled up like a rug or carpet. A farmer living in the vicinity told me that the Crows visited the place every day to feed upon the grubs that destroyed the turf in this way. The grubs or larvæ were about three-fourths of an inch in length; body whitish, with some dull plumbeous underneath; head blackish.

Many other reports of similar work might be cited, but the above will suffice. We may add, however, that, judging from the numerous reports received, Crows regularly visit new-mown fields for the purpose of eating the grasshoppers thus left exposed. Probably a score of observers have noted this fact in their reports.

DO CROWS EAT POTATO BEETLES?

Among the reports received are six or more which mention the potato bug or potato beetle among the insects which are eaten by the Crow. George H. Berry, of North Livermore, Me., says:

It eats grasshoppers, potato bugs, and *Cleisiocampa* larvæ [tent caterpillars].

Charles W. Beckwith, of Frederickton, Canada, says:

It eats the Colorado potato beetle to a small extent, not enough to be of much apparent benefit.

W. E. Dingman, of Newton, Iowa, says:

I have observed it feeding on the potato bug and grasshoppers, quite extensively on June 21, 1886.

Other observers make similar statements, while still others say that it has never been seen to eat this beetle at all, and even appears to shun it altogether. Mr. W. B. Hall, of Wakeman, Ky, states that he could not in any way tempt his tame Crows with potato bugs. His account of the insect-eating habits of his pets is so interesting and suggestive that it is inserted here entire:

Crows are decidedly insectivorous if domestication does not alter their habits. At different times I have kept Crows which were taken from the nest when nearly full fledged. They became very tame so that I had a chance to watch their actions and manner of feeding. I find that they are not particular in their diet as to

whether the insect is what is termed injurious or beneficial. They feed greedily on the different species of cut-worm (*Agrotis*), and on the white grub (larva of *Lachnosterna fusca*). When plowing they will follow in the furrow and pick up every grub or beetle in sight; and when their appetites are satisfied they fill their beaks with insects and hide them under sticks, leaves, or stones. I have often taken the pains to look up their hiding places and count the insects thus hidden and I have been astonished at the numbers. They kill predaceous beetles but do not often eat them, I think on account of the peculiar odor most of them emit. For the sake of experiment, I have taken the Crows to a board or stone which on being removed exposed many black beetles (mostly *Galerita*). They would pounce on a beetle, give it a pinch through the head or thorax, drop it, and seize another with such rapidity that but few if any escaped. I could not on any condition tempt their appetites with Colorado beetles, squash bugs, cucumber bugs, or any of the soldier bugs or lady birds (*Coccinella*). I had a male Crow that would eat the cabbage caterpillar (*Pieris rapæ*) with evident relish while his mate disdained such plebeian diet. They would kill the sow bugs (*Oniscus*) and species of Myriapoda, but would not eat them.

THE INSECT FOOD OF THE CROW AS REVEALED BY EXAMINATION OF STOMACHS.

Among the eighty-six stomachs of the Common Crow examined, sixty-three were found to contain insect remains, and these remains were submitted to the Entomologist of the Department, Prof. C. V. Riley, who caused a critical study of them to be made, and has in preparation a full report, showing the number and kinds of insects represented in each stomach, with notes as to their habits and economic importance. A brief summary of the more important facts brought out by this investigation is given herewith. It has been prepared by the writer from a preliminary report to the Entomologist by Tyler Townsend, assistant, who, with the aid of the other members of the entomological force, made most of the determinations. The full report will appear in a bulletin on the Crow, which is now in preparation in the Ornithological Division.

The stomachs examined contained the remains of about ninety-two species of true insects, represented by about five hundred specimens. About 10 per cent. of these can not be classed properly as either beneficial or injurious, and the remainder are divided pretty evenly between the two. The following table shows the orders represented, as well as the number of species and individuals in each, and these are further classified under the heads beneficial, injurious, and neutral:

Table showing the nature of the insect food in sixty-three stomachs of the Common Crow.

	Species.				Individuals.			
	Beneficial.	Injurious.	Neutral.	Total.	Beneficial.	Injurious.	Neutral.	Total.
Hymenoptera	16	1	0	17	126	8	0	134
Lepidoptera	0	6	0	6	0	16	0	16
Diptera	1	0	0	1	1	0	0	1
Coleoptera	23	16	8	47	85	57	32	174
Hemiptera	1	1	1	3	1	1	1	3
Orthoptera	0	17	0	17	0	150	0	150
Neuroptera	0	0	1	1	0	0	18	18
Total	41	41	10	92	213	232	51	496

In addition to the true insects mentioned above, the stomachs contained remains of at least three species of spiders and two of myriapods, sixteen specimens in all, and all beneficial.

The order Coleoptera (beetles) is most numerously represented, and a majority of the species are beneficial. It is an interesting fact that no less than eighteen species of predaceous beetles (*Cicindelidæ* and *Carabidæ*) are included in this number, together with nearly a dozen species of the scavenger beetles (*Scarabæidæ*). Some of these are species possessing disagreeable odors, and it is somewhat surprising that the Crow should take them unless other food was scarce. They occur most abundantly, however, in stomachs taken in May, June, and July, when other food must have been abundant. Among the injurious beetles identified are the flat-headed apple-tree borer (*Chrysobothris*), of which a single specimen was found; May beetles (*Lachnosterna*) in five stomachs (nine specimens in one); and a few other borers and leaf-feeders. Three small weevils were taken from one stomach and considered "injurious insects," as they are, but it is probable that they were hidden in kernels of corn which were eaten by the Crow.

The order Orthoptera (grasshoppers, crickets, etc.) is well represented by one hundred and fifty specimens belonging to seventeen species. Twenty-eight stomachs contained examples of this order, and the results of stomach examination in this case bear out the statements of observers and show that in this direction the work done by the Crow is entirely beneficial, as all these insects are more or less injurious.

The order Hymenoptera, including the wasps, bees, ants, etc., is represented, in the material taken from the Crow stomachs, by one hundred and thirty-four specimens belonging to seventeen species, all but one of which are beneficial. A species of saw-fly, decidedly injurious, was found in one stomach, and seven larvæ of the same or another species in a second stomach. One of these stomachs, however, also contained the remains of a young bird, apparently a nestling, and it is not improbable that the saw-flies came from this source. Two other stomachs contained remains of ichneumon flies belonging to different genera. These are among the most beneficial of insects, destroying particularly large numbers of caterpillars.

Only one other order requires special mention, viz, the Lepidoptera. In this are included the butterflies and moths, the larvæ of which are almost invariably destructive. Contrary to what might have been expected, the Crow stomachs do not show many representatives of this order. Six species, five of which are decidedly injurious, were recognized, but the sixteen specimens were distributed among nine stomachs. The family *Noctuidæ*, which includes the cut-worms, was represented by nine specimens in six stomachs; that is, but six Crows out of eighty-six had eaten any cut-worms.

In concluding this imperfect summary of the insectivorous habits of the Common Crow it must be conceded that the showing is not very favorable for the bird.

Considering merely the testimony of observers, the conclusion would be favorable in the main, for it appears that the Crow eats insects throughout the season, at many times in large quantities, and often of the most injurious kinds. To be sure they are mainly terrestrial or subterranean kinds, but they are decidedly injurious in the main, and few if any beneficial insects are said to be taken.

In the light of the stomach examinations, however, the case assumes a different complexion, for although the evidence from this source confirms in some respects the testimony of observers, it indicates also that beneficial and injurious insects are taken in

nearly equal quantities, and thus the good done at one time may be fully neutralized at another. The force of this point is much weakened by the small number of stomach examinations made, and by the fact that so few Crows were taken during the summer months; but the *indications* point to an omnivorous habit in general, and to the destruction of good and bad insects indiscriminately.

As has been suggested by many previous writers and reiterated by numbers of our own observers, the harm done in the destruction of eggs and young of insectivorous birds during spring and early summer is beyond all computation; and it is difficult for one familiar with the magnitude of the Crow's iniquity in this direction to believe that any destruction of injurious insects or other animals can fully atone for it. Yet even here another factor should be taken into account, as it must be borne in mind that many of the small birds killed by the Crow are not strictly insectivorous, while some of them, in their thefts of fruit and other crops, continually tend to even their own accounts with the farmer, and occasionally even overdraw them.

THE CROW AS AN ENEMY TO FIELD MICE AND OTHER SMALL QUADRUPEDS.

Aside from the insect-eating habits of the Crow its most beneficial trait probably is the killing of field mice. Of these it is a great destroyer, hunting up the nests and devouring young and old whenever they can be caught. There is abundance of evidence that Crows are very skillful at such hunting, and undoubtedly they form one of the strong checks on the increase of these prolific and destructive rodents. Among the reports of our correspondents are twelve which mention this habit of mouse-hunting, and from these we select a few:

From James O. Whittemore, Fairfield, Me.:

I have observed Crows catching insects and field-mice all the year round. The general impression among farmers is to tolerate Crows at all seasons except the early spring.

From O. P. Hitchings, Winfield, N. Y.:

The Crow has the reputation of catching field-mice, especially just after the grass has been cut.

From F. A. Sampson, Sedalia, Mo.:

After mowing I have seen Crows feeding on what I supposed to be grasshoppers; they also catch and eat mice.

We have received one report also from William J. Howerton, of Florence, Ariz., who writes as follows:

The Common Crow of this section is of some economic value, as I have observed it catching and killing the common pocket gopher.

MISCELLANEOUS ANIMAL FOOD OF THE CROW.

Probably no family of birds in existence is more truly omnivorous than the Crows; almost anything eatable is utilized when hunger presses, though at other times they are more scrupulous about their food. It is useless, therefore, to attempt to give a complete category of the items which may enter into the Crow's diet, and as many of them have no bearing on the economic aspects of the question it is

unnecessary to dwell on the subject here; any one who is curious to know exactly what ninety-eight Crows had eaten just before they were killed can consult the list of stomach examinations with which this paper concludes.

The animal matter contained in the stomachs of eighty-six Common Crows examined was as follows:

Animal contents of stomachs.	No. of stomachs in which found.
Carrion	14
Remains of mice	4
snake	1
frogs	5
salamander	1
fish	9
crayfish	6
other crustaceans	5
mussels or clams	4
snails of various kinds	6
insects	63
spiders	2
myriapod	1

The following statement from Mr. John M. Richardson, of Daingerfield, Tex., is interesting in this connection from its novelty. Mr. Richardson writes:

The Crow is known to catch young terrapins, and there is reason to believe that it destroys other small reptiles. I remember a rock-crowned hill on the east bank of the Wateree, between Manchester and Statesburgh, in Sumter County, Ga., that was almost covered with remains of small terrapins and land tortoises carried there, killed, and devoured by Crows.

THE CROW AS A SCAVENGER.

The eighty-six stomach examinations of the Common Crow showed food in but fourteen cases which could properly be called carrion; but it is a well-known fact that during seasons of scarcity Crows eat large quantities of carrion. Nevertheless the good done in this way has been very greatly overestimated, for it is almost certain that they prefer fresh food to carrion, and only take the latter when more agreeable food is scarce. This is mainly during winter and early spring when, in cold climates, no harm would be done if the carrion were allowed to lie uneaten.

During warm weather, when the decay of animal substances is more unpleasant and perhaps more dangerous to health, the Crow rarely touches a carcass at all, but any animal which dies at that time, together with any carcasses left from earlier in the season, are soon disposed of by insects and the natural processes of desiccation and decay.

In warm climates the black vultures and turkey buzzards render the services of Crows entirely superfluous. Undoubtedly there are times when Crows are serviceable in the removal of carrion, but in most cases there is no excuse for its presence in places where it can do any harm.

Food of the Fish Crow.

The food of the Fish Crow has been represented usually as consisting more strictly of marine products than that of the Common Crow; and it has been supposed also not to pull corn or feed on ripening grain, but to devote more time to fruit and perhaps to insects.

The examination of the twelve stomachs of Fish Crows does not bear out all these statements, for no one of the stomachs contained any trace of fish or any marine product, except a few bits of shell in one stomach. Only three of the stomachs contained any traces of insects (these mostly grasshoppers), while five contained carrion, and eight contained grain and berries. No one of these stomachs contained any seeds of poison ivy or sumach.

SUMMARY OF EVIDENCE FROM ALL SOURCES.

It appears, therefore, from a careful consideration of all testimony, published and unpublished, that—

I. Crows seriously damage the corn crop, and injure other grain crops usually to a less extent.

II. They damage other farm crops to some extent, frequently doing much mischief.

III. They are very destructive to the eggs and young of domesticated fowls.

IV. They do incalculable damage to the eggs and young of native birds.

V. They do much harm by the distribution of seeds of poison ivy, poison sumach, and perhaps other noxious plants.

VI. They do much harm by the destruction of beneficial insects.

On the other hand—

VII. They do much good by the destruction of injurious insects.

VIII. They are largely beneficial through their destruction of mice and other rodents.

IX. They are valuable occasionally as scavengers.

The careful examination of large numbers of stomachs, and the critical study of the insect food of the Crow, may change materially the present aspect of the question; but so far as the facts at present known enable a judgment to be formed, the harm which Crows do appears to far outweigh the good.

RESULTS IN DETAIL OF THE EXAMINATION OF STOMACHS OF THE COMMON CROW (CORVUS AMERICANUS).

[NOTE.—The following records of dissection are from examinations of stomachs preserved in alcohol and forwarded to the Department of Agriculture by the collectors whose names accompany the records in the list below. Unless otherwise stated the determinations of the various items of stomach contents have been made entirely by members of the Division, the writer being responsible for the larger part. The percentages of the food elements in each case are to be regarded simply as approximate; they are merely careful estimates, no exact measurement being practicable. As elsewhere stated, the remains of insects were referred to the Entomologist of the Department, for critical study, and a summary of his preliminary report has been given on a previous page.]

2648. Male. Schraalenburgh, N. J. January 2, 1886; 9.30 a. m. F. J. Dixon.
Animal matter, 0 per cent.; vegetable, 90; gravel, etc., 6; indeterminate, 4. Stomach less than half full.
Contents.—Fragments of corn, acorns, etc.; 3 bits of insect legs; fine mud-like matter not determined; a little sand and gravel.

2649. Female. Schraalenburgh, N. J. January 2, 1886; 10.30 a. m. F. J. Dixon.
Animal matter, 7 per cent.; vegetable, 90; gravel, etc., 3. Stomach well filled.
Contents.—Remains of corn; pumpkin and cucumber seeds, and perhaps other seeds; remains of muscular fiber, probably from a mussel or clam as some of it was attached to a piece of a shell, apparently that of bivalve; a few bits of shell and a little sand; no remains of insects.

7012. Chester County, Pa. January 12, 1887. Dr. B. H. Warren.
Animal matter, 25 per cent.; vegetable, 50; gravel, etc., 25. Stomach about two-thirds full.
Contents.—A few bits of corn (kernels), and a large amount of hulls of corn or other grain, with some other vegetable fiber; 4 seeds of poison ivy (*Rhus toxicodendron*); 2 vertebræ of small bird* and several fragments of bone of small fish*; 3 or 4 small beetles and a large quantity of other insect remains, and one spider; a good supply of coarse gravel.

7013. Chester County, Pa. January 15, 1887. Dr. B. H. Warren.
Animal matter, 1 per cent.; vegetable, 90; gravel, etc., 9. Stomach about three-fourths full.
Contents.—One hundred and fifty-three seeds of poison ivy (*Rhus toxicodendron*), about 125 seeds of sumach (*Rhus glabra*); egg-case of a spider; insect remains; a fair amount of sand and gravel; a quantity of finely pulverized vegetable matter mixed with fine sand.

4432. Male. East Hartford, Conn. January 15, 1887; a. m. Willard E. Treat.
Animal matter, 10 per cent.; vegetable, 75; gravel, etc., 15. Stomach well filled.
Contents.—Remains of kernels of corn, forming about 70 per cent. of entire stomach contents; about 15 seeds of common sumach (*Rhus*) and 1 seed of poison sumach (*Rhus venenata*); about 10 per cent. of bits of flesh and ligament of some animal, probably carrion; a large amount of clean sand without pebbles; no insect remains.

4433. Female. East Hartford, Conn. January 15, 1887; a. m. Willard E. Treat.
Animal matter, 15 per cent.; vegetable, 10; gravel, etc., 75. Stomach less than half full.
Contents.—Three unknown seeds, probably of apple, pear, or quince; a small amount of vegetable matter like pulp of fruit; a single hog bristle and a number of bits of meat, probably carrion; a large amount of sand without any gravel or pebbles; no insect remains.

4434. Female. East Hartford, Conn. January 16, 1887; a. m. Willard E. Treat.
Animal matter, 15 per cent.; vegetable, 10; gravel, etc., 75. Stomach about half full.
Contents.—A few skins of berries or seeds in small bits, and a little other fine vegetable débris; a single hog bristle and bits of animal tissue, probably carrion; about 2 per cent. of insect remains, all of a single insect; a large amount of sand, and two or three small pebbles.

4435. Male. East Hartford, Conn. January, 16, 1887; 2 p. m. Willard E. Treat.
Animal matter, 5 per cent.; vegetable, 3; gravel, etc., 92. Stomach almost empty.
Contents.—One or two hog bristles and a few shreds of animal membrane, probably carrion; a few bits of hulls of corn or other grain; a little sand and many small fragments of some hard black mineral; no insect remains.

4436. Female. East Hartford, Conn. January 16, 1887; 2 p. m. Willard E. Treat.
Animal matter, 35 per cent.; vegetable, 60; gravel, etc., 5. Stomach about half full.
Contents.—About 100 seeds of poison ivy (*Rhus toxicodendron*), and 7 seeds of common sumach (*Rhus*); about 35 per cent. of shreds and bits of animal membrane, probably carrion; a little sand, and five or six small pebbles; no insects.

4437. Male. East Hartford, Conn. January 16, 1887; 2 p. m. Willard E. Treat.
Animal matter, 40 per cent.; vegetable, 10; gravel, etc., 50. Stomach almost empty.
Contents.—Two seeds of harmless sumach (*Rhus*) and a few hulls and skins of other seeds or grain; one hog bristle and a few shreds and small masses of muscle and tendon, probably carrion; sand without pebbles; no insects.

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*These bones were identified by F. A. Lucas.

4438. Male. East Hartford, Conn. January 16, 1887; 2 p. m. Willard E. Treat.
Animal matter, 14 per cent.; vegetable, 85; gravel, etc., 1. Stomach well filled.
Contents.—Remains of about 20 kernels of corn, 9 or 10 of them nearly entire; about 80 seeds of harmless sumach (*Rhus*); one or two hog bristles, and many shreds and bits of meat, probably carrion; a very little sand; no insects.

4450. Female. East Hartford, Conn. January 31, 1887; 10 a. m. Willard E. Treat.
Animal matter, 5 per cent.; vegetable, 48; gravel, etc., 47. Stomach well filled.
Contents.—Remains of kernels of corn, mostly hulls; one or two small shreds of meat (carrion?); a dozen or more caddis-fly cases and some of the legs of the larvæ [Tyler Townsend]; a large amount of sand and gravel.

4451. Male. East Hartford, Conn. January 31, 1887; 10 a. m. Willard E. Treat.
Animal matter, 50 per cent.; vegetable, 50; gravel, etc., 0. Stomach less than half full.
Contents.—Scraps and shreds of meat and animal membrane (carrion?); about 120 seeds of harmless sumach (*Rhus*), and other remains of the berries; no gravel or sand; no insects.

4452. Male. East Hartford, Conn. January 31, 1887; 10 a. m. Willard E. Treat.
Animal matter, 50 per cent.; vegetable, 42; gravel, etc., 8. Stomach well filled.
Contents.—Shreds and tendinous masses of animal matter, probably carrion; remains of a few acorns or chestnuts; 77 seeds of poison ivy (*Rhus toxicodendron*); about 175 seeds of harmless sumach (*Rhus*); a small amount of gravel and sand; no insects.

3059. Male. Sandy Spring, Md. February 4, 1887; a. m. H. H. Miller.
Animal matter, 0 per cent.; vegetable, 87; gravel, etc., 10; indeterminate, 3. Stomach well filled.
Contents.—Corn almost entirely, more than half of it in large pieces, some nearly entire kernels and a large quantity of hulls; about 10 per cent. of gravel and sand, the bulk of it being rusty quartz; a small amount (3 per cent.) of fine "mud," not identifiable; no insects.

4461. East Hartford, Conn. February 14, 1887; 10 a. m. Willard E. Treat.
Animal matter, 40 per cent.; vegetable, 50; gravel, etc., 10. Stomach well filled.
Contents.—Remains of corn and perhaps other grains, with a few bits of grass and hulls of seeds; about 60 seeds of harmless sumach (*Rhus*), apparently of two distinct species; 2 seeds of red cedar (*Juniperus*); a large amount of muscular fiber, fat, and sinews, probably carrion; sand and gravel; no insects.

4462. Female. East Hartford, Conn. February 14, 1887; 10 a. m. Willard E. Treat.
Animal matter, 5 per cent.; vegetable, 45; gravel, etc., 50. Stomach nearly empty.
Contents.—Remnants of corn and hulls; a few bits of acorn shells; a bit of skin (without hair) of some animal; a single hog bristle; a fair amount of fine sand, and two or three small pebbles; no insects.

4463. Female. East Hartford, Conn. February 14, 1887; 10 a. m. Willard E. Treat.
Animal matter, 1 per cent.; vegetable, 45; gravel, etc., 50; indeterminate, 4. Stomach about half full.
Contents.—About 100 seeds of harmless sumach (*Rhus*), and a considerable amount of hulls, skins, etc., of these or other seeds and fruits; a few minute bits of the hard parts of insects; a little very fine black "mud," not determined; sand, gravel, and bits of coke.

4464. Male. East Hartford, Conn. February 14, 1887; 10 a. m. Willard E. Treat.
Animal matter, 75 per cent.; vegetable, 0; gravel, etc., 25. Stomach almost empty.
Contents.—One hog bristle; a very little muscular fiber and sinew and some fat, doubtless all carrion; a small amount of fine sand; no insects.

3139. Male. West Goshen, Pa. February 15, 1886. Dr. B. H. Warren.
Animal matter, 5 per cent.; vegetable, 93; gravel, etc., 2. Stomach about half full.
Contents.—Remains of numerous kernels of corn; 6 seeds of sumach; a small bone from tarsus or carpus of some animal, apparently of the size of a dog or sheep; a single piece of slate about one-half inch long; no insects.

1331. Male. Washington, D. C. March 13, 1886; 4 p. m. Dr. A. K. Fisher.
Animal matter, 1 per cent.; vegetable, 97; gravel, etc., 2. Stomach well filled.
Contents.—Unidentified vegetable matter mainly; a few bits of corn or other grain, with some hulls, bits of grass, and what appears to be young sprouts of some vegetable; 3 or 4 small seeds not identified; a single claw of a crayfish and a few bits of insect remains: no pebbles and very little sand.

1379. Young. Saint Louis, Mo. May 23, 1885. Otto Widmann.
Animal matter, 99 per cent.; vegetable, 0; gravel, etc., 1.
Contents.—Many bones of frog; numerous fragments of insects; a very little sand.

5510. Nestling. Gainesville, Va. May 13, 1887; 5 p. m. Dr. A. K. Fisher.
Animal matter, 90 per cent.; vegetable, 0; gravel, etc., 0; indeterminate, 10. Stomach well filled.
Contents.—Mainly insects; a few bones of a small frog; about 10 per cent. of fine "mud," apparently a mixture of animal, vegetable, and mineral matter, but not determinable; no sand or gravel.

5511. Nestling. Gainesville, Va. May 13, 1887; 5 p. m. Dr. A. K. Fisher.
Animal matter, 90 per cent.; vegetable, 7; gravel, etc., 1; indeterminate, 2. Stomach about two-thirds full.
Contents.—Six or eight small pieces of vegetable matter, apparently bits of an acorn or chestnut; a few shreds of vegetable fiber; 2 or 3 minute bones of a fish; 3 bits of shell, probably of snail; a single small pebble and a few grains of sand; a large amount (nearly 90 per cent.) of insect remains, among which pieces of beetles are numerous; a small amount of fine mud-like material, probably from the insects.

2514. Adult female. Sing Sing, N. Y. June 30, 1886; 3 p. m. Dr. A. K. Fisher.
Animal matter, 1 per cent.; vegetable, 99; gravel, etc., 0. Stomach full.
Contents.—Mainly corn, one whole kernel and many large pieces, and a large amount of hulls and finely pulverized corn; 3 stones of cherries (cultivated); a few bits of black vegetable material like the shell of an acorn; a few bits of the hard parts of beetles; no sand or gravel.

2677. Young. Englewood, N. J. June 27, 1886; 5 p. m. F. M. Chapman.
Animal matter, 95 per cent.; vegetable, 5; gravel, etc., 0. Stomach well filled.
Contents.—Remains of a small bird, apparently an unfledged young; remains of insect larvæ and insects, but these *may* have come from the stomach of the young bird eaten by the Crow; a few bits of the hulls of corn, and other vegetable débris.

3045. Adult (?). Peterborough, Madison County, N. Y. June, 1886. G. S. Miller, jr.
Animal matter, 3 per cent.; vegetable, 95; gravel, etc., 2. Stomach well filled.
Contents.—Kernels of corn, oats, and a few of wheat, together with a large quantity of hulls, mainly of oats; a few small fragments of insects; 4 small pebbles, and a very little sand.

3769. Male. Immature. Peck's Island, New Jersey. July 1, 1886; noon. J. Percy Moore.
Animal matter, 15 per cent.; vegetable, 10; gravel, etc., 75. Stomach about half full.
Contents.—Mainly sand and bits of shell; two or three bits of seaweed and a very little other vegetable matter; 1 gasteropod shell about half an inch long; 3 or 4 joints of a crustacean's legs; hundreds of minute fish vertebræ, almost microscopic; about 5 per cent. of insect remains in very fine pieces.

2515. Male. Immature. Sing Sing, N. Y. July 1, 1886; 9 a. m. Dr. A. K. Fisher.
Animal matter, 99 per cent.; vegetable, 0; gravel, etc., 0; indeterminate, 1. Stomach about half full.
Contents.—Insects, mainly larvæ; a few bits of what appears to be bark or wood, but not positively identified; no sand or gravel.

2516. Male adult. Sing Sing, N. Y. July 1, 1886; 9 a. m. Dr. A. K. Fisher.
Animal matter, 2 per cent.; vegetable, 95; gravel, etc., 3. Stomach well filled.
Contents.—Nine cherry stones, with skins and pulp of about 3; fragments of corn or other grain, and the hulls of same; about 20 seeds of *Rubus* sp.? and 6 or 8 unknown seeds; a few remains of insects, apparently beetles; 5 small pebbles and a little sand.

Dr. Fisher says the cherry stones are from cherries which grow everywhere in the woods about Sing Sing, and probably have escaped from cultivation. They are very dark when ripe, almost black.

2517. Male adult. Sing Sing, N. Y. July 1, 1886; noon. Dr. A. K. Fisher.
Animal matter, 65 per cent.; vegetable, 33; gravel, etc., 2. Stomach well filled.
Contents.—Seven cherry stones (like those in No. 2516), and bits of skins and other débris of fruit; about a dozen seeds of *Rubus*, apparently the red raspberry (*R. strigosus*); large quantity of insect remains, one or two insects nearly entire; a very small amount of sand.

2518. Male adult. Sing Sing, N. Y. July 1, 1886; 1 p. m. Dr. A. K. Fisher.
Animal matter, 70 per cent.; vegetable, 30; gravel, etc., 0. Stomach full.
Contents.—Nineteen cherry stones (like those in No. 2516); a few bits of fruit skins and vegetable fiber; a very large amount of insect remains; four small vertebræ of small, tailed batrachian, perhaps a salamander (identified by F. A. Lucas).

2519. Male adult. Sing Sing, N. Y. July 2, 1886; 10.30 a. m. Dr. A. K. Fisher.
Animal matter, 60 per cent.; vegetable, 40; gravel, etc., 0. Stomach well filled.
Contents.—Six cherry stones (like those in No. 2516), and a very little other vegetable matter; bones and flesh of a small bullfrog (identified by F. A. Lucas). No trace of insects or gravel.

2520. Female adult. Sing Sing, N. Y. July 2, 1886; 1 p. m. Dr. A. K. Fisher.
Animal matter, 50 per cent.; vegetable, 50; gravel, etc., 0. Stomach little distended.
Contents.—Five stones of cherry (like those in No. 2516); remains of insects; no gravel.

2521. Female adult. Sing Sing, N. Y. July 2, 1886; 1.30 p. m. Dr. A. K. Fisher.
Animal matter, 60 per cent.; vegetable, 40; gravel, etc., 0. Stomach nearly empty.
Contents.—One cherry stone (like those found in No. 2516), and a single fragment of some other fruit stones; insect remains; no gravel.

2522. Female adult. Sing Sing, N. Y. July 2, 1886; 2.30 p. m. Dr. A. K. Fisher.
Animal matter, 33 per cent.; vegetable, 65; gravel, etc., 2. Stomach well filled.
Contents.—Four cherries, whole or nearly so, and stones of twelve more (like those in No. 2516), with a very little other vegetable matter; bones of a frog, forming about four-fifths of the animal matter, the remainder being fragments of insects; a single pebble and a very little sand.

2678. Young. Nigger Pond, Ramapo Mountains, N. J. July 4, 1886; 5 p. m. F. M. Chapman.
Animal matter, 10 per cent.; vegetable, 90; gravel, etc., 0. Stomach nearly empty.
Contents.—A few pieces of acorns, peas, or kernels of corn; three or four small berries, probably of the heath family, perhaps blueberries (*Vaccinium*); two or three pieces of animal matter, possibly bits of marine worms; two or three bones of small fish; no sand or gravel.

2679. Young. Nigger Pond, Ramapo Mountains, New Jersey. July 4, 1886; 5 p. m. F. M. Chapman.
Animal matter, 3 per cent.; vegetable, 97; gravel, etc., 0. Stomach about half full.
Contents.—Numerous fragments of the flesh of some nut, fruit, or grain, not determined, perhaps of acorn, as there are many fragments of shell resembling that of an acorn; 2 pistils of flowers nearly an inch long; a few bones of small fish; no trace of insects or gravel.

2866. Male adult (?). Peterborough, Madison County, N. Y. July 14, 1886. G. S. Miller, jr.
Animal matter, 60 per cent.; vegetable, 30; gravel, etc., 4; indeterminate, 6. Stomach well filled.
Contents.—Remains of oats (mainly the hulls); fine grass and some other vegetable fiber; bones and nearly all the teeth of a field-mouse (*Arvicola riparius*), forming about 25 per cent. of the whole stomach contents; about 30 per cent. of insect remains; about 6 per cent. of fine "mud" not identifiable.

4886. Young. Hillsborough, New Brunswick, July 15, 1886; 3 to 4 p. m. Jonathan Dwight, jr.
Animal matter, 10 per cent.; vegetable, 45; gravel, etc., 45. Stomach nearly empty.
Contents.—Remains of seeds and berries, two kinds of seeds not recognized; remains of insects; 10 pebbles; no sand.

4887. Male, young. Hillsborough, New Brunswick. July 16, 1886; 8 a. m. Jonathan Dwight, jr.

Animal matter, 35 per cent.; vegetable, 65; gravel, etc., 0. Stomach less than half full.

Contents.—A piece of moss about half an inch long; hulls of five or six raspberries; seven seeds of red raspberry (*Rubus strigosus*); remains of a large cutworm; no gravel or sand.

4888. Female, young. Hillsborough, New Brunswick. July 16, 1886; 8 a. m. Jonathan Dwight, jr.

Animal matter, 1 per cent.; vegetable, 99; gravel, etc., 0. Stomach less than half full.

Contents.—Hulls and a few seeds of raspberry; two small, unknown pods not yet ripe; twelve or fifteen very small seeds, possibly those of strawberries; a single fragment of some beetle; no gravel or sand.

4962. Male, immature. Hillsborough, New Brunswick. July 29, 1886; 5. p. m. Jonathan Dwight, jr.

Animal matter, 20 per cent.; vegetable, 80; gravel, etc., 0. Stomach about half full.

Contents.—A large amount of pulp and skins of some fruit not identified (the pulp looks like that of an early apple, but the skins are too thin); two stones of some species of *Prunus*, perhaps a beech plum; remains of insects, mainly (?) beetles, but one large cutworm; no gravel.

735. Immature. Sing Sing, N. Y. September 18, 1885; 10 a. m. Dr. C. Hart Merriam.

Animal matter, 5 per cent.; vegetable, 60; gravel, etc., 20; indeterminate, 15. Stomach well filled.

Contents.—Twenty-two stones of wild cherry (*Prunus serotina*); 9 of cornel (*Cornus* sp.?), and 3 unidentified; also pulp of above berries; a few pieces of what appears to be an acorn or chestnut; various hard parts of insects.

1540. Alfred Centre, N. Y. September 20, 1885; a. m. F. S. Place.

Animal matter, 45 per cent.; vegetable, 53; gravel, etc., 2. Stomach full.

Contents.—Fragments of the "meat" of some nut or large seed; pieces of acorns or chestnuts; numerous fragments of fruit pulp, probably apple; many insect remains (45 per cent.); 5 small pebbles; no sand.

1541. Alfred Centre, N. Y. September 20, 1885; a. m. F. S. Place.

Animal matter, 40 per cent.; vegetable, 60; gravel, etc., 0, Stomach full.

Contents.—Seven stones of wild cherry (*Prunus serotina*); 5 or 6 triangular seeds (of *Polygonum ?*); skins and other vegetable matter from both the preceding, and some long vegetable fiber from some other plant; numerous insect remains; no sand or gravel.

2239. Male. Washington, D. C. September 7, 1886; 11 a. m. W. B. Barrows.

Animal matter, 0 per cent.; vegetable, 70; gravel, etc., 5; indeterminate, 25. Stomach almost empty.

Contents.—One grape seed; vegetable fiber finely divided; 2 or 3 bits of sand and gravel; fine mud-like material, not identifiable; no insects.

2240. Male. Washington, D. C. September 7, 1886; 11 a. m. F. A. Lucas.

Animal matter, 10 per cent.; vegetable, 80; gravel, etc., 10. Stomach about half full.

Contents.—Grape seeds and skins, with a little pulp and much vegetable fiber; other vegetable material not identifiable; 7 seeds of poison ivy; small amount of gravel; a few insect remains.

The grape seeds are undoubtedly those of cultivated grapes, as this bird and No. 2239 were shot near a vineyard, the owner of which complained of the great damage done by the Crows.

2698. Alfred Centre, N. Y. September 7, 1886. F. S. Place.

Animal matter, 95 per cent.; vegetable, 5; gravel, etc., 0. Stomach less than half full.

Contents.—One stone of wild cherry and a very little fine vegetable matter, probably from the fruit of the same; several grasshoppers and perhaps other insects; no gravel.

2242. Male. Shelter Island, New York. September 11, 1886; a. m. W. W. Worthington.

Animal matter, 10 per cent.; vegetable, 85; gravel, etc., 5. Stomach well filled.

Contents.—about 50 seeds of bay-berry or wax-berry (*Myrica cerifera*); hulls of corn or some other grain, with a few small bits of the grain; a little fine vegetable material, not identified; remains of the legs of a small crustacean; 4 small snail shells (marine); 2 vertebræ of small fish; a few fragments of insects; a little sand.

4587. Male. Shelter Island, New York. October 1, 1886; a. m. W. W. Worthington.
Animal matter, 25 per cent.; vegetable, 60; gravel, etc., 15. Stomach about half full.
Contents.—Fragments of acorns or chestnuts, and, perhaps, of some other seeds, but these mainly; remains of a crayfish; 4 or 5 minute bits of an insect; considerable sand, but no pebbles.

4588. Male. Shelter Island, New York. October 1, 1886; a. m. W. W. Worthington.
Animal matter, 0 per cent.; vegetable, 100; gravel, etc., 0. Stomach less than half full.
Contents.—Remains of a dozen or more kernels of corn; about 50 stones of bay-berry (*Myrica cerifera*); a single stone of some wild *Prunus*, probably the beach plum (*P. maritima*); 3 small claw tips of a crab or crayfish, probably taken as gravel (?); no insects.

2269. Female, adult. Sing Sing, N. Y. October 2, 1886; 3 p. m. Dr. A. K. Fisher.
Animal matter, 2 per cent.; vegetable, 95; gravel, etc., 3. Stomach full.
Contents.—Nineteen seeds of flowering dogwood (*Cornus florida*); 17 seeds of bay-berry (*Myrica cerifera*); bits of shell of chestnuts and large amount of chestnut "meat;" 8 vertebræ and other small bones of a small fish; minute bits of the shell of insects; little sand and gravel.

1439. Essex Junction, Vt. October 3, 1885; 10 a. m. Charles A. Davis.
Animal matter, 1 per cent.; vegetable, 10; gravel, etc., 89. Stomach nearly empty.
Contents.—Skin and pulp of a single fruit, perhaps a grape, but no seeds; large quantity of sand and gravel; minute fragments of the hard parts of insects.

1444. Winfield, N. Y. October 4, 1885; 10 a. m. O. P. Hitchings.
Animal matter, 5 per cent.; vegetable, 5; gravel, etc., 85; indeterminate, 5.
Contents.—A few bits of oats and perhaps other grain; a mixture of finely pulverized vegetable and mineral matter, forming a fine black mud; a large amount of sand and pebbles; a few fragments of insects.

2564. Female. Broadway, Queens County, N. Y. October 16, 1886; noon. William Dutcher.
Animal matter, 18 per cent.; vegetable, 75; gravel, etc., 7. Stomach well filled.
Contents.—Remains of acorns or chestnuts; remains of insects; gravel, including many bits of shell.

1141. Adult. Sing Sing, N. Y. October 18, 1885. Dr. A. K. Fisher.
Animal matter, 10 per cent.; vegetable, 75; gravel, etc., 10; indeterminate, 5. Stomach well filled.
Contents.—Fragments of acorns or chestnuts; about 50 seeds of poison sumach; remains of various insects; skins and pulp of a few berries.

1515. Watkins, N. Y. October 20, 1885; 8.45 a. m. H. C. Griswold.
Animal matter, 25 per cent.; vegetable, 25; gravel, etc., 50. Stomach about half full.
Contents.—Fragments of seeds, one of which appears to be that of a squash or melon; a little unidentifiable vegetable matter; remains of insects; sand and gravel.

3940. Male. Rockville, Conn. October 22, 1886. H. K. James.
Animal matter, 60 per cent.; vegetable, 35; gravel, etc., 5. Stomach full.
Contents.—Remains of some large seed, possibly corn or beans of some kind; large quantity of insect remains, mainly grasshoppers; small quantity of gravel, mostly bits of quartz, but one fair-sized garnet.

4080. Male. East Hartford, Conn. October 22, 1886; noon. C. C. Hanmer.
Animal matter, 2 per cent.; vegetable, 96; gravel, etc., 2. Stomach full.
Contents.—Remains of acorns or chestnuts almost entirely, and mainly without any bits of shell; a small amount of insect fragments in very small bits; a few pieces of charcoal, and a very little sand.

1460. Male. Redford, Mich. October 26, 1885; 7 a. m. (Killed over corn-field.) William J. Muldragh.
Animal matter, 0 per cent.; vegetable, 99; gravel, etc., 1. Stomach about half full.
Contents.—Mainly fragments of the pulp or flesh of some nut or berry, possibly acorns; 2 grape seeds; 3 small pebbles, no sand; no insect remains; no traces of corn.

1201. Male. Washington, D.C. October 30, 1885; 4 p.m. Dr. C. Hart Merriam.
Animal matter, trace; vegetable, 89 per cent.; gravel, etc., 5; indeterminate, 5. Stomach well filled.
Contents.—Twenty or thirty kernels of corn in fragments; 21 stones of flowering dogwood (*Cornus florida);* 125 seeds of poison ivy; sand and gravel, and what appears to be fine mud; no trace of insect remains.

1202. Female. Washington, D. C. October 30, 1885, 4 p. m. Dr. C. Hart Merriam.
Animal matter, 1 per cent.; vegetable, 94; gravel, etc., 5. Stomach full.
Contents.—About 40 seeds of Virginia creeper (*Ampelopsis quinquefolia*); about 50 seeds of grapes (*Vitis*), at least 2 species; about 20 seeds of poison ivy, 1 of poison sumach, and 30 more unidentified; pulps and skins of grapes and other fruit; bits of sea-weed, grass, and unrecognizable vegetable matter; a few bits of insects; sand, gravel, 2 or 3 bits of mollusk shell, and single, worn claw of crayfish.

1250. Female. Washington, D. C. November 14, 1885; 11.30 a. m. Dr. A. K. Fisher.
Animal matter, 8 per cent.; vegetable, 90; gravel, etc, 2. Stomach full.
Contents.—Nine seeds of Virginia creeper (*Ampelopsis*); 12 stones of flowering dogwood (*Cornus florida*); fragments of about 5 kernels of corn; a few hairs of a small mammal (probably mouse); 1 very small gasteropod shell; bones of the head of a small fish; minute fragments of one insect.

2301. Adult. Washington, D. C. November 7, 1886; 4.30 p. m. H. W. Henshaw.
Animal matter, 10 per cent.; vegetable, 65; gravel, etc., 20; indeterminate, 5. Stomach full.
Contents.—Remains of acorns, chestnuts, and perhaps other seeds; a single grape seed, and some hulls of corn or other grain, with much fine vegetable matter like saw-dust; a considerable amount of sand and gravel; remains (fine) of many insects.

1709. Male. Calhoun, Ga. November 28, 1885. R. Windsor Smith.
Animal matter, 75 per cent.; vegetable, 10; gravel, etc., 15.
Contents.—Twenty-four seeds of poison ivy; a small snake, 8 inches or more in length; a small snail (*Helix*); 1 very large spider; remains of many insects, constituting almost 40 per cent. of entire stomach contents; 4 or 5 pebbles of the size of kernels of corn, and some sand; a very little undetermined vegetable matter.

1518. Male. Watkins, N. Y. December 15, 1885; 4 p. m. H. C. Griswold.
Animal matter, 12 per cent.; vegetable, 63; gravel, etc., 25. Stomach full.
Contents.—Remains of corn, acorns, or chestnuts; some other seeds too much comminuted to determine; numerous insect remains; large quantity of gravel.

4600. Male. Rockaway Beach, Long Island, N. Y. December 17, 1885. Jonathan Dwight, jr.
Animal matter, 95 per cent.; vegetable, 0; gravel, etc., 5. Stomach nearly empty.
Contents.—The animal matter of one or more shell-fish (apparently a mussel and a barnacle, as bits of shell belonging to these are also contained); a very little sand; no insects.

1269. Female. Washington, D. C. December 2, 1885; 4 p. m. Dr. A. K. Fisher.
Animal matter, 1 per cent.; vegetable, 75; gravel, etc., 20; indeterminate, 4.
Contents.—Fragments of 1 or 2 acorns or chestnuts; large quantities of the "skin" or hulls of grain, apparently of kernels of corn; 30 seeds of poison ivy; large amount of sand and gravel; some vegetable fiber and mud; numerous but small fragments of the hard parts of insects.

1297. Female. Washington, D. C. December 17, 1885; found dead. Dr. A. K. Fisher.
Animal matter, 90 per cent.; vegetable, 2; gravel, etc., 8. Stomach about one-fourth full.
Contents.—One cocoon of some insect, and 2 smaller cocoons, or egg-bags of spider; 12 or 15 small fragments of much-worn bone, perhaps taken as "gravel;" a few bits of vegetable membrane, apparently epidermis of some grain; a very small amount of sand and gravel.

1298. Washington, D. C. December 17, 1885; found wounded. Dr. A. K. Fisher.
Animal matter, 5 per cent.; vegetable, 85; gravel, etc., 8; indeterminate, 2.
Contents.—Remains of 3 or 4 kernels of corn and the hulls of many more; 90 to 100 seeds of common sumach, apparently *Rhus glabra;* fragments of insects; gravel and sand; about 2 per cent. of fine mud-like material, not determined.

1299. Female. Washington, D. C. December 19, 1885; 4-5 p. m. Dr. A. K. Fisher. Animal matter, 1 per cent.; vegetable, 80; gravel, etc., 19. Stomach well filled.

Contents.—Seven seeds of harmless sumach; a large amount of vegetable matter, part of which may be bits of corn, acorns, etc., but the bulk seems more like sea-weed; a few fragments of the hard parts of insects; a large amount of gravel and fine sand, with 2 or 3 bits of shell.

1300. Male. Washington, D. C. December 19, 1885; 4-5 p. m. Dr. A. K. Fisher. Animal matter, 0 per cent.; vegetable, 90; gravel, etc., 10. Stomach well filled.

Contents.—Fragments of corn; 75 seeds of poison ivy; 60 seeds of common sumach and 1 seed of grape; gravel and bits of coal and brick; no insect remains.

1301. Male. Washington, D. C. December 19, 1885 : 4-5 p.m. Dr. A. K. Fisher. Animal matter, trace; vegetable, 75 per cent.; gravel, etc., 24. Stomach well filled.

Contents.—" Mast " (*i e.*, acorns, chestnuts, and similar material), and large quantities of the epidermis of some grain, perhaps corn; 68 seeds of poison ivy; large amount of sand, gravel, etc.; minute fragments of insects.

1302. Male. Washington, D. C. December 19, 1885; 4-5 p.m. Dr. A. K. Fisher. Animal matter, 1 per cent.; vegetable, 85; gravel, etc., 14. Stomach well filled.

Contents.—Fragments of many kernels of corn, and two entire kernels; about 15 seeds of common sumach; 30 seeds of poison ivy; sand, gravel, and 5 or 6 good-sized bits of mother-of-pearl; a few small fragments of insects, and one insect nearly entire.

1303. Female. Washington, D. C. December 19, 1885; 4-5 p.m. Dr. A. K. Fisher. Animal matter 1 per cent.; vegetable, 94; gravel, etc. 5. Stomach well filled.

Contents.—About 20 whole kernels of corn, and fragments of as many more; 7 seeds of grape; about 60 seeds of common sumach; 5 seeds of poison ivy; gravel, coal, and sand; a few remains of insects.

1304. Male. Washington, D. C. December 19, 1885; 4-5 p.m. Dr. A. K. Fisher. Animal matter, 5 per cent.; vegetable, 70; gravel, etc., 25. Stomach about two-thirds full.

Contents.—About 10 entire kernels of corn (without skins), and as much more in fragments; 2 seeds of poison ivy; gravel, and bits of coal; about 5 per cent. of insect remains.

1311. Male. Washington, D. C. December 23, 1885; 4-5 p.m. Dr. A. K. Fisher. Animal matter, 10 per cent.; vegetable, 60; gravel, etc., 30. Stomach full.

Contents.—Particles of wheat or corn, 3 or 4 kernels in all; 100 seeds of common sumach; remains of sea-weeds and other vegetable matter; remains of a few small crustaceans (perhaps isopods); fragments of mussel shell with parts of the mussel attached; minute pieces of insects; considerable sand, and many pebbles.

1312. Male. Washington, D. C. December 23, 1885; 4-5 p.m. Dr. A. K. Fisher. Animal matter, 40 per cent.; vegetable, 50; gravel, etc., 10. Stomach full.

Contents.—One kernel of corn nearly entire, pieces of several more, and a large amount of hulls and other vegetable débris; 20 or 25 seeds of harmless sumach, apparently of two species; remains of a small crab or crayfish; 10 or 12 small bones of a fish; numerous remains of insects (grasshopper legs, etc.), and pieces of myriapods; sand, gravel, and pebbles, with 1 or 2 bits of shell.

1313. Male. Washington, D. C. December 23, 1885; 4-5 p. m. H. W. Henshaw. Animal matter, 1 per cent.; vegetable, 15; gravel, etc., 70; indeterminate, 14. Stomach full.

Contents.—Seeds and gravel mainly, with a little mud and fine vegetable refuse; traces of insects in addition to 2 or 3 small beetles entire; about forty seeds of common sumach, and about 80 of poison ivy; a few small bits of some grain, in all equal to about two kernels of wheat. Among the gravel was a small, worn, crayfish claw.

1314. Male. Washington, D. C. December 23, 1885; 4-5 p. m. H. W. Henshaw. Animal matter, 10 per cent.; vegetable, 60; gravel, etc., 30. Stomach full.

Contents.—Pieces of corn, perhaps 4 or 5 kernels in all; bits of grass, hulls, vegetable fiber of various kinds, and considerable fine "mud," apparently all vegetable; 6 or 8 pieces of the carapace of a crayfish; fragments of mussel shell (*Unio ?*); many small bones of common mouse (*Mus musculus*), with some of the teeth; many fragments of insects, much comminuted; sand, gravel, charcoal, and one or two imperfect snail shells.

1315. Male. Washington, D. C. December 23, 1885; 4–5 p. m. H. W. Henshaw.
Animal matter, 1 per cent.; vegetable, 97; gravel, etc., 2. Stomach well filled.
Contents.—Mainly kernels of corn whole or in fragments, and the hulls of same; bits of the shell of acorns and a few bits of the kernel of same; 4 seeds of poison ivy; 1 seed of bind-weed, (*Polygonum?*); about 100 very small, black seeds; a very few fragments of insects; a very little gravel or sand.

1316. Female. Washington, D. C. December 23, 1885; 4–5 p. m. H. W. Henshaw.
Animal matter, 3 per cent.; vegetable, 72; gravel, etc., 25. Stomach about half full.
Contents.—A few bits of corn and hulls of same; pieces of grass and very fine vegetable débris, part of it apparently the shell of some bony seed; 4 or 5 small beetles, and minute portions of hard parts of others; sand and gravel; small tuft of mammal's hair, probably of cat or dog; fragments of one or more legs of crayfish; eight or ten kernels of wild rice (*Zizania aquatica*); 2 unknown seeds.

1317. Female. Washington, D. C. December 23, 1885; 4–5 p. m. H. W. Henshaw.
Animal matter, 2 per cent.; vegetable, 83; gravel, etc., 15. Stomach about three-fourths full.
Contents.—Mainly pieces of corn and hulls of same; 123 seeds of poison ivy; a little fine vegetable matter not determined; minute pieces of the hard parts of insects; gravel and fine sand form about 15 per cent. of the entire contents.

2528. Male. Washington, D. C. December 25, 1886. F. A. Lucas.
Animal matter, 5 per cent.; vegetable, 50; gravel, etc., 25; indeterminate, 20. Stomach well filled.
Contents.—Remains of acorns, chestnuts, and similar material, in small pieces; about 20 per cent. of other vegetable material, similar in color, but like fine mud, and probably part vegetable and part sand; bones of a small fish, forming 4 or 5 per cent. of contents; a single leg of some insect, and 2 or 3 other minute insect fragments; gravel, consisting mainly of mother-of-pearl and fine sand.

4117. Female. East Hartford, Conn. December 15, 1886; 10 a. m. C. C. Hanmer.
Animal matter, 15 per cent.; vegetable, 60; gravel, etc., 20; indeterminate, 5. Stomach well filled.
Contents.—Remains of acorns, both shells and "meat;" a few bits of thorn-apple (*Cratægus*), but no seeds; bits of grass and finely divided vegetable matter; a considerable amount of fine, dark hair, probably of mouse; perhaps 5 per cent. of insect remains; a large amount of pebbles and sand; about 5 per cent. of fine "mud" not determined.

RESULTS IN DETAIL OF THE EXAMINATION OF STOMACHS OF THE FISH CROW (CORVUS OSSIFRAGUS).

1332. Male. Washington, D. C. March 16, 1886; 4 p. m. Dr. A. K. Fisher.
Animal matter, 5 per cent.; vegetable, 93; gravel, etc., 2. Stomach full.
Contents.—Eleven seeds of cat-brier (*Smilax glauca*); 2 seeds of sour gum (*Nyssa multiflora*); a few bits of corn and many hulls, together with other fibrous vegetable matter; 2 small masses of animal fiber, apparently flesh of some mammal; single feather, probably of chicken; a very little sand, etc.; no insect remains.

1333. Female. Washington, D. C. March 16, 1886; 4 p. m. Dr. A. K. Fisher.
Animal matter, 10 per cent.; vegetable, 88; gravel, etc., 2. Stomach about half full.
Contents.—Two or three kernels of corn, and hulls of more, with some other vegetable matter; bone of some mammal (probably taken with gravel); 2 or 3 feathers, kind not determined; among the gravel was a bit of shell (of *Unio?*) and several bits of egg-shell (hen's); no insects.

1334. Female. Washington, D. C. March 16, 1886; 4 p. m. Dr. A. K. Fisher.
Animal matter, 98 per cent.; vegetable, trace; gravel, etc., 2. Stomach about one-third full.
Contents.—A mass of meat and sinews, doubtless carrion; a very few small bits of coal and sand, and one or two bits of egg-shell (hen's); a very few vegetable fibers, perhaps of grass; no insects.

1335. Male. Washington, D. C. March 16, 1886; 4 p. m. Dr. A. K. Fisher.
Animal matter, 75 per cent.; vegetable, 5; gravel, etc., 20. Stomach about one-third full.
Contents.—Shreds of meat, and strips and small sheets of animal membrane, not identifiable, doubtless carrion; a few bits of grass and woody fiber; particles of sand and pebbles, and numerous small pieces of egg-shell (hen's), together with fragments of a mussel shell (*Unio ?*), and 2 small bones, apparently mammalian, but discolored and probably taken as gravel; no insects.

1336. Washington, D. C. March 16, 1886; 4 p. m. Dr. A. K. Fisher.
Animal matter, 5 per cent.; vegetable, 75; gravel, etc., 5; indeterminate, 15. Stomach about half full.
Contents.—Mainly remnants of oats with the hulls, and corn in fine pieces; a little meat fiber; a few downy feathers; 3 or 4 unknown seeds; some sand and gravel and bits of egg-shell (hen's); no insects.

657. Female, immature. Sing Sing, N. Y. September 10, 1885; 6.30 a. m. Dr. A. K. Fisher.
Animal matter, 0; vegetable, 100. Stomach half full.
Contents.—Fragments of oats, pieces of acorns or chestnuts; unrecognizable vegetable matter; no traces of animal food.

2529. Male. Washington, D. C., November 1, 1886. F. A. Lucas.
Animal matter, 10 per cent.; vegetable, 90; gravel, etc., 0. Stomach about two-thirds full.
Contents.—Seeds, pulp, and skins of about 20 poke-berries (*Phytolacca decandra*); remains of two or three grasshoppers, and perhaps other insects; no gravel.

2284. Male. Washington, D. C., November 1, 1886; 3 p. m. F. A. Lucas.
Animal matter, 65 per cent.; vegetable, 30; gravel, etc., 5. Stomach well filled.
Contents.—Five grape seeds, pieces of grape skins, many fragments of grasshoppers (and other insects ?), a little sand, bits of egg-shell, one scale from shell of a tortoise, probably all taken as gravel.

2302. Female. Washington, D. C., November 7, 1886; 4.30 p. m. H. W. Henshaw.
Animal matter, 35 per cent.; vegetable, 65; gravel, etc., 0. Stomach well filled.
Contents.—Seeds and skins of about 20 small grapes, apparently "frost grapes" (*Vitis cordifolia*); about 130 seeds of poke-berry (*Phytolacca*); heads, wings, and legs of several grasshoppers; no gravel or sand except one small piece of mica.

2583. Male. Washington, D. C., November 19, 1886; 9.30 a. m. William Dutcher.
Animal matter, 50 per cent.; vegetable, 50; gravel, etc., 0. Stomach nearly empty.
Contents.—Three seeds of poke-berry and one or more skins of same; 3 seeds of red cedar (*Juniperus virginiana*); no insect remains; no gravel.

1310. Male. Washington, D. C. December 23, 1885; 4–5 p. m. Dr. A. K. Fisher.
Animal matter, 1 per cent.; vegetable, 96; gravel, etc., 3. Stomach about half full.
Contents.—Two or three grains of wheat, and many fragments of this or other grain; 2 seeds of Virginia juniper; many fragments of some black, bony seed, looking much like ground coffee; 2 or 3 small "pin feathers" still inclosed in the sheath except at tip; many small fragments of egg-shell (hen's); a very little sand, and 1 bit of stone; no trace of insect remains.

1318. Female. Washington, D. C. December 25, 1885; 4–5 p. m. Dr. A. K. Fisher.
Animal matter, 50 per cent.; vegetable, 50; gravel, etc., 0.
Contents.—Meat (probably carrion); 8 seeds of sour gum (*Nyssa multiflora*); 4 seeds of flowering dogwood, 1 seed of grape, 5 seeds of hackberry (*Celtis occidentalis*), 2 unknown seeds; no gravel or insect remains.

THE ROSE-BREASTED GROSBEAK

(*Habia ludoviciana*).

AN ENEMY TO THE COLORADO BEETLE OR POTATO BUG.

As early as 1873 Mr. Henry H. Mapes noted the fact that the Rose-breasted Grosbeak fed freely on potato bugs near Kalamazoo, Mich. (*Am. Naturalist*, VII, 493). In the same journal, in 1875, W. F.

Bundy made the following statement with regard to this habit of the Grosbeak at Jefferson, Wis.:

I noticed last summer that great numbers of the Colorado potato beetle were destroyed by the Rose-breasted Grosbeaks. The farmers hold these birds in great favor, and are very careful to prevent their destruction. They were so abundant in this region last summer as to hold in check the vast army of these ravagers of the potato crop. (*Am. Naturalist*, IX, p. 375.)

Since this time the habit has been noticed repeatedly throughout the country, and in 1885 reports of this kind were received at the Department of Agriculture from the states of Connecticut, Illinois, Iowa, Michigan, Minnesota, New Jersey, and New York.

In 1886 Prof. F. E. L. Beal, formerly of Ames, Iowa, wrote as follows:

The Rose-breasted Grosbeak feeds upon the Colorado potato beetle in all its stages. I observed this habit in central Iowa, and noticed that each year it became more general, the birds of this species seeking the potato-field more and more each season. I observed one small field near my house that was much infested with the beetles, but the birds found it, and in a few weeks I searched the field but could not discover a single beetle, young or old.

From many reports received since, we select the following:

From M. R. Steele, Decorah, Iowa:

As the Rose-breasted Grosbeak raises only one brood, and devours many Colorado potato bugs, which many other birds do not eat, it deserves special encouragement. Farmers know its value.

From George H. Selover, Lake City, Minn.:

The Rose-breasted Grosbeak is thought, and with reason, too, to be beneficial on account of its destroying the potato bug. It is the only bird I have observed that would come under this head. It destroys the common potato bug very extensively; so extensively, in fact, as to deserve the name of "Potato-bug bird" given it in so many localities.

From E. M. Hancock, Waukon, Iowa:

The Rose-breasted Grosbeak has more than made amends for its pea-stealing by its determined warfare upon the Colorado potato beetle, helping very materially to keep down this pest.

From Orville L. Larkin, East Otto, N. Y.:

I have been observing the habits of the Rose-breasted Grosbeak and would say that it is a decided enemy of the Colorado beetle, devouring both the larva and the mature beetle, shucking the wings off from the latter much as the canary does the hulls from bird seed.

From B. T. Gault, Chicago, Ill.:

The Rose-breasted Grosbeak may be regarded as the farmer's friend on account of its fondness for the Colorado potato beetle and chinch-bug.

These reports show that this bird already is a valuable friend of the farmer and is deserving of the most careful protection and encouragement. The little harm which it is known to do—solely the destruction of a few peas, small fruits, and buds or blossoms—is trifling in comparison with the value of its services in the potato-field. Moreover it is one of the most beautiful of all our native birds, and in addition to its striking plumage has a pleasant warbling song which is constantly heard during the nesting season.

In some of our smaller Eastern cities this species nests freely in the shade trees and hedges along the streets, as well as in the gardens and orchards about the houses; and doubtless in most cases all that is needed in order to secure its presence more generally is the provision of suitable trees and shrubbery for nests, and the assurance that its young and eggs will not be molested.

REPORT OF THE DIRECTOR OF THE OFFICE OF EXPERIMENT STATIONS.

SIR: I have the honor to present the report of the Office of Experiment Stations.

As the office was not organized until October its organization, preliminary work, and plans thus far made are all that can be reported upon at this date.

Respectfully,

W. O. ATWATER,
Director.

Hon. NORMAN J. COLMAN,
Commissioner of Agriculture.

ESTABLISHMENT AND FIRST WORK OF THE OFFICE OF EXPERIMENT STATIONS.

The report of the Commissioner of Agriculture to the President has stated briefly the occasion for the establishment of this office, the legislation regarding it, and the duties it is properly called upon to perform.

The Office of Experiment Stations was established October 1, 1888. Its work thus far has been mainly that of organization and the collection of material to be used in future publications. At the outset it put itself in communication with the colleges and stations throughout the country. One of the first things done was the preparation of an address list of the stations, containing the legal name of each, the name and titles of its director, its location, and post-office address. As many of the stations were but recently organized, this list could not be made sufficiently accurate for publication until after the considerable delay occasioned by the passage of numerous letters to and fro between the office and the widely scattered stations. This address list has been supplemented by an organization list, containing, in addition, the name of the college with which each station was connected, the name and title of the president or other chief officer of the college, the legal designation and constitution of the governing board, with the name of each member, and the name, title, and work of each member of the station staff.

The office has begun a library of station publications, which it hopes to make not only a complete collection of all the publications of the stations organized under national authority, but also of all those issued by the stations previously established in the United States. A card catalogue of the library is kept up to date. Steps

have also been taken toward the collection of a general library for the use of the office.

October 12, a circular was sent out to agricultural colleges and experiment stations, asking for information concerning the organization, board of management, faculty or working force, courses of study or methods of work, experimental investigations, equipment, revenue, means for publishing results and disseminating information, history, peculiarities, and tendencies of each. The information obtained in response to this circular and by an extensive supplementary correspondence is being incorporated in a report on agricultural science and education in the United States for the coming Paris Exposition. A considerable number of photographs illustrating the buildings, apparatus, farms, live-stock, etc., of various colleges and stations have been collected to form an exhibit at the same exposition.

Data regarding the history of the general movement for the promotion of agricultural science and education in the United States have also been collected. A brief outline of this history will be published in the Paris Exposition report. It is expected that the work thus far done in this direction will be the basis for a more adequate history of this movement, to be published by the office as soon as practicable.

PUBLICATIONS CONTEMPLATED.

Just what publications will best meet the needs of the stations on the one hand, and on the other convey the fruits of their work to the public whom they are intended to serve, experience must decide.

Bulletins of two classes are now being planned. In those of the one class, which may, perhaps, be called "farmers' bulletins," it is the purpose to collate the results of station work bearing upon special topics and the teachings of other research, and put the whole into a form so plain that the intelligent farmer will understand it, so brief that he will read it through, and so practical that he will take it to heart. Thus, while each station is distributing its own results to the farmers of its own State, this instrumentality will help the several stations to be serviceable to the agriculture of the whole country. The bulletins of the other class, which may, with like propriety, be called "experiment-station bulletins," will be intended more especially for station workers and others interested in the more abstract scientific matters.

Bulletins of both these classes are begun. A series of monographs on special topics is also contemplated, in accordance with the recommendations of the committee on station work of the Association of American Agricultural Colleges and Experiment Stations, published by the Department of Agriculture nearly a year ago. The following passages are from that report:

> There is a quite general call for condensed statement of what is being done by the stations and a number wish to know specifically in advance what the others are proposing to do. The desire for compilation of methods and results of work already done in this direction in this country, and especially in Europe, is earnestly, though less frequently, expressed, and those who are most familiar with that work are the ones who lay the most stress on its being made available to our workers, in order that they may avoid useless repetition of work already done and avail themselves of what is known as to what is most needed to be done and how to do it.
>
> In entering upon the study of a given problem it is essential to know not only what has already been found out, but in what direction further inquiry can best be prosecuted and what experience has to say as to the ways and means. This is, at

the bottom, merely the assertion of the obvious principle that the first condition of successful research is full knowledge of what has been done.

Some of the problems proposed for study, especially those in the newer States and Territories, are comparatively new, but the majority are of essentially the same kinds that have been engaging the attention of experimenters for many years. Such are those connected with the chemistry and physics of the atmosphere and soil; the exhaustion of the soil and the restoration of its fertility by tillage and manures; the composition of plants and their adaptation to different localities and conditions; the feeding of animals, the production of milk, butter, and cheese, and other matters connected with the dairy; the diseases of plants and animals, fruit culture, and numerous other subjects. To one familiar with the history of this sort of research it is interesting to note how many of the problems suggested for study by the different stations are nearly or quite identical with those with which work of the experiment stations was begun when the first ones were founded over thirty years ago, and how large a proportion are in fact the same that have been the object of the bulk of the study of these and other institutions of research in this country, in England, and to a far larger extent on the continent of Europe, for half a century.

A large number of the stations will necessarily labor under the disadvantage of inexperience. In other countries the growth of experiment stations has been gradual, and new ones have been established no faster than skilled experts were ready to man them; but in this country the enterprise is being enlarged suddenly and to an extent previously unheard of. The difficulties which the newer stations have to meet from this source are enhanced by the fact that nearly all of the accumulated experience is recorded in foreign literature, and accessible only to those who have at hand the great accumulation of journals and other publications in which the results of earlier and later research are set forth.

The committee are strongly of the opinion that one of the most useful services to the cause would consist in the compilation of the main results of this research in various special lines and the putting of them not only into English but in forms conveniently suited to the use of the American investigators. This service would be appreciated as warmly by those who have long endeavored to follow up the literature and are constantly and painfully reminded of their inability to keep themselves well posted in its details as by those who have paid less attention to them.

The form and range which these publications will most advantageously assume must of course be decided by experience.

While the object of such monographs would be to give the gist of accumulated experience upon specific topics, bringing the facts down to the date of preparation, accounts of current research are likewise greatly needed. In just what way this need will be met it is impracticable at this date to say, but the matter is receiving earnest consideration.

WORK OF INVESTIGATION.

The report of the committee on station work above referred to contained the following statements suggested by extensive correspondence with stations:

Through the communications from representatives of the stations above cited there runs the evident conviction of the importance of doing the kind of work which shall be most directly useful to the farmer. The continued support of the stations will depend upon their success not only in meeting the wants of the agricultural public, but making that public feel that they do so.

With reference to this matter the committee venture two suggestions. One has already been urged. It is that a part of the duty of the stations is to teach, but to teach only well-attested and useful facts. By publishing information in terse, simple language, with appropriate explanations, by attending farmers' meetings, and demonstrating in lectures and otherwise the things that farmers need and desire to know; by interesting farmers in experimental work, and securing their co-operation in carrying it out. In short, by diligent effort to carry knowledge to the farmer and help him with it, and at the same time help him to help himself, the workers in the stations will both do their duty and secure the support they need. Such is the experience of experiment stations and agricultural colleges. There is more than one of our most successful institutions which would not be in existence to-day if it had not done a deal of faithful work of this sort.

The other is that, while the stations are under obligations to select for study the questions of immediate practical interest, yet oftentimes those which on the surface appear theoretical are at the bottom the most practical. The seemingly simplest and most pressing problems reach down to the profoundest depths of abstract law, and not infrequently the practical interests of the farmer require the theoretical problems to be considered first, for the same reason that the foundations of a house and not the wall is the first to be built.

Doubtless it is well that the new stations should go through more or less of the same experience that the older ones have, in commencing with concrete practical questions and gradually working toward the study of the laws that underlie them. This will involve loss of time, energy, and money, in the sense that oftentimes the main result of an experiment will be to show the need of studying a problem that lies beneath it. But this will not be an entire loss, for such experiments often bring valuable information even if the goal is not reached, and they are means of showing the constituency of the stations the need of abstract research. Indeed positive good in many ways comes from just such work and experience. The wisdom consists in insuring the minimum of waste.

It is important to know what fertilizers will be most profitable in New Jersey or in Ohio; what forage plants will best withstand the colds of New Hampshire and Dakota; what fruits may be successfully grown in Iowa and Delaware; how cotton seed may be advantageously composted in Alabama or fed to stock in Mississippi or Texas. These are local questions, and will be solved mainly by practical tests made and interpreted in the light of the best knowledge.

It will help farmers to know what are the most economical rations wherever cattle are fed and the best ways of making butter and cheese wherever there is dairying. These questions involve more of general laws and are less affected by local conditions.

But whether a given problem is influenced more or less by local circumstances, it is always controlled by general law. The action of fertilizers depends upon the chemistry and physics of the soil and the physiology of the plant; the making of butter upon the chemical and physical properties of milk; the production of meat and milk upon laws of nutrition; and all these properties and laws are still very imperfectly understood.

Unquestionably the stations ought to make practical experiments in the study of the problems before them. But in the long run, those stations will do best that plan their work most philosophically, and the prosperity of the enterprise as a whole will be proportioned to its success in the discovering of the laws that underlie the right practice of agriculture.

In brief, the ultimate success of the stations will depend upon the discovery of principles. This is accomplished only by patient, profound, costly research, no small part of which has to do with the finding out of the best methods of investigation of special problems. But while this work is essential, the stations are confronted with the necessity of doing what will directly and immediately help the farmer. The need and value of abstract research are not understood. To show its usefulness and help prepare the way for the stations to prosecute it, and at the same time do some of the things that are most immediately and pressingly needed in these directions, will be one of the important ways in which the Department can aid the experiment station enterprise.

GENERAL STATEMENTS.

Measures have been undertaken to aid in the co-ordinating of the work of the stations and to facilitate co-operation where that is needed. These are being very materially aided by the action of the Association of American Agricultural Colleges and Experiment Stations. Of course this is one of the most important phases of the work of the Department in its connection with the stations, but its successful performance involves no little consultation with the institutions interested and deliberation in the laying of plans so that the best ultimate results will come from efforts which may seem at first rather tardy in their realization.

The cordial appreciation with which the efforts made by this office have been received by the stations and colleges, the readiness with which they have responded to its requests for information, and the earnestness with which they have rallied to its support are most gratifying evidences of the favor with which its establishment is regarded. The number of inquiries for information and requests for assistance, not only from the stations and colleges but from other organizations and from private individuals in this and other countries, demonstrate most clearly its opportunity for usefulness.

The following brief account of the development of the experiment station movement in the United States, prepared by Dr. A. C. True, of this office, from data collected for the above-mentioned report for the Paris Exposition, may not be out of place here:

ORIGIN AND DEVELOPMENT OF AGRICULTURAL EXPERIMENT STATIONS IN THE UNITED STATES.

By A. C. TRUE, Ph. D.

In the United States, as in Europe, the first organized experimental work in agricultural science was done in connection with the higher educational institutions.

It is believed that Yale College was the first American institution to officially recognize the claims of agricultural science. In 1846 John P. Norton was appointed professor of agricultural chemistry and vegetable and animal physiology. Professor Norton began his lectures in 1847, and during the five years which intervened before his death he also wrote extensively for agricultural journals, edited an American edition of "Stevens on the Farm," and published a work of his own entitled "Elements of Agriculture." After the fund which had been established by the sale of the land-scrip donated to Connecticut under the act of Congress of July 2, 1862, had been given to the Sheffield Scientific School of Yale College in 1863, a professor of agriculture was added to the working force of that institution. Samuel W. Johnson, M. A., the successor of Professor Norton as professor of theoretical and agricultural chemistry, and William H. Brewer, Ph. D., the professor of agriculture, have for many years taken an active interest in all work for the promotion of agricultural science in Connecticut and elsewhere in the United States. Under their direction experimental work for the benefit of agriculture was carried on to a limited extent at New Haven more than twenty years ago. And it is doubtless safe to say that "through the influence of the professors and pupils trained in this school, more than to any other single cause, is due the recognition of the importance of the establishment of agricultural experiment stations, first in Connecticut and subsequently throughout the whole country."

In 1870 the president and fellows of Harvard College began to organize the school of agriculture and horticulture which had been provided for in the will of Mr. Benjamin Bussey, of Roxbury, Mass. This interesting document was signed July 30, 1835, and was proved soon after the death of the testator in 1842. It bequeathed half of the income of about $300,000, and 200 acres of land in Roxbury, to the President and Fellows of Harvard College, on condition that they establish on the farm "a course of instruction in practical agriculture, in useful

and ornamental gardening, in botany, and in such other branches of natural science as may tend to promote a knowledge of practical agriculture and the various arts subservient thereto." Owing to other provisions of the will, it was not deemed advisable to begin the formation of the Bussey Institution earlier than 1870. In the same year, the trustees of the Massachusetts Society for Promoting Agriculture granted to the corporation of Harvard College a considerable sum "for the support of a laboratory and for experiments in agricultural chemistry to be conducted on the Bussey estate." The laboratory of the new institution was not ready for occupation until the last week in 1871. As soon as it was completed, however, agricultural researches were begun by F. H. Storer, the professor of agricultural chemistry, and his assistants. The first report of work done was presented to a committee of the trustees of the Massachusetts Society for Promoting Agriculture, December 3, 1871. The experiments consisted of field tests of fertilizers upon the farm of the institution, and chemical analyses of commercial fertilizers. Other interesting and valuable work was done in the next few years, but the great fire in Boston, in 1872, and the commercial crisis of 1873, combined to cripple the institution financially, and it has since been able to make comparatively few original investigations. Meanwhile, agricultural colleges had been organized in a number of the States. Michigan led the way in 1857, and New York soon followed her example. After the passage of the land-grant act in 1862, Kansas and Massachusetts were the first States to avail themselves of the national gift by establishing agricultural colleges, and thereafter the formation of these institutions proceeded with as much rapidity as could have been expected when the country was recovering from the direful effects of the civil war. Experimental work in agriculture was undertaken in several of these institutions soon after their organization.

The reports of the successful and beneficial work done in the European experiment stations excited more and more attention on this side of the Atlantic, and the more advanced leaders in agricultural progress in this country began to ask for the establishment of similar institutions in the United States. In 1872, at a convention of representatives of agricultural colleges held in Washington in response to a call issued by the Commissioner of Agriculture, the question of the establishment of experiment stations was discussed, and the report of a committee in favor of such institutions was adopted by the convention.

On the 17th of December, 1873, at the winter meeting of the State Board of Agriculture, at Meriden, Conn., Professor Johnson, of the Sheffield Scientific School, and Professor Atwater, of Wesleyan University, urged the establishment of an agricultural experiment station in that State after the European pattern. A committee was appointed to consider the expediency of such a movement, and reported two days later that it was "their unanimous opinion that the State of Connecticut ought to have an experiment station as good as can be found anywhere, and that the legislature ought to furnish the means for its establishment." A permanent committee was then appointed by the board to bring this matter to the attention of the public and the legislature. This committee held meetings in different parts of the State, and the following winter secured the introduction of a bill for an experiment station, which, however, was laid over until the next session of the legislature. Another year of agitation of the

matter ensued. The project had many warm and enthusiastic friends, but, as might have been expected, the great mass of the farmers took little interest in the enterprise. When it had become apparent that it could not succeed, Mr. Orange Judd, the editor of the American Agriculturist, offered on his own part $1,000 to begin the undertaking, and on the part of the trustees of Wesleyan University at Middletown the free use of the chemical laboratory in the Orange Judd Hall of Natural Science, donated by him to that institution. These offers were made on the condition that the legislature should appropriate $2,800 per annum for two years for the work of the station. It was thought that if by these means the work of agricultural experimentation could be actually begun the usefulness of the enterprise would be so clearly demonstrated that it would speedily be given more generous and permanent support. An act making the appropriation thus proposed was unanimously passed and approved July 2, 1875. Early in October of the same year a chemist was on the ground, and as soon as practicable two assistants were secured. Professor Atwater was made director, and thus the first agricultural experiment station in America was an accomplished fact.

A considerable amount of experimental work, chiefly on commercial fertilizers, was done with the limited means at the disposal of this first American agricultural experiment station. At the expiration of the two years provided for in the original bill the station was reorganized under the more direct control of the State and removed to New Haven, where it has since been in successful operation, first in rooms of Sheffield Hall, free use of which was granted by the Sheffield Scientific School, and later in buildings and grounds in the suburbs of New Haven, for the purchase and improvement of which the legislature provided $25,000 in 1882.

The success which attended this first attempt to establish an organized experiment station in the United States was sufficient to attract the attention of advanced agriculturists throughout the country, and March 12, 1877, the State of North Carolina established a similar station at Chapel Hill in connection with the State University.

The Cornell University Experiment Station was organized in February, 1879, by the faculty of agriculture of the University, as a voluntary organization. From that time until the passage of the act of Congress of March 2, 1887, the work was carried on by the different professors in time which could be spared from other studies. For a part of that time the trustees of the University appropriated money from the University funds to pay for the services of an analyst and for the purchase of supplies. All the other work was done without compensation. The New Jersey State Station, at New Brunswick, N. J., was established March 18, 1880, by an act of the State legislature, and connected with the Scientific School of Rutgers College. The movement grew in favor with the people with each succeeding year, and in 1886 the Committee on Agriculture, in reporting the Hatch bill to the House, was able to make the following statements:

> Since 1881 the legislatures of several States have either recognized or reorganized the departments of agriculture in the land-grant colleges as "experiment stations," thus following substantially the course adopted by New Jersey. Such stations have been established in Maine, Massachusetts, Ohio, Tennessee, Wisconsin. In three other States (possibly more), without legislative action, the college authorities have organized their agricultural work as experiment stations. This has been done in California, Missouri, and New York; but in addition to the twelve experiment stations specifically designated by that name, a very large number of colleges established under the act of 1862 are doing important work of a precisely similar kind.

Many of them began such work immediately upon their establishment, and have maintained it continuously; others have entered upon it more recently. The colleges in Colorado, Indiana, Kansas, Michigan, and Pennsylvania are carrying on what is strictly experiment-station work as a part of their ordinary duty.

The convention of delegates of agricultural colleges, which met at Washington in 1883, discussed and indorsed the project for the establishment of stations in connection with the colleges by appropriations from the national Treasury, in accordance with the terms of a bill already introduced in the House of Representatives by C. C. Carpenter, of Iowa. Congress, however, was not yet quite ready to undertake so large a scientific enterprise in this direction, and the bill was not put upon its passage. Meanwhile, the number of stations was steadily increasing, and the interest of practical farmers, as well as men of science, was more and more excited by the reports of the results of the experiments which the stations had completed. On the 8th of July, 1885, a convention of agricultural colleges and experiment stations met at the Department of Agriculture at Washington in response to a call issued by the Commissioner of Agriculture. Almost the first thing which this convention did was to pass a resolution—

That the condition and progress of American agriculture require national aid for the investigation and experimentation in the several States and Territories; and that, therefore, this convention approves the principle and general provisions of what is known as the Cullen bill of the last Congress, and urges upon the next Congress the passage of this or a similar act.

(The "Cullen bill" was in its general provisions similar to the bill afterwards passed by Congress and now known as the Hatch act.)

So earnest was the convention in this matter that it appointed a committee on legislation, which was very efficient in securing the passage of the amended bill.

In a later session the convention passed resolutions urging the creation of a branch of the Department of Agriculture which should be a special medium of intercommunication and exchange between the colleges and stations, and which should publish a periodical bulletin of agricultural progress, containing in a popular form the latest results in the progress of agricultural education, investigation, and experimentation in this and in all countries. Provision was also made for a permanent organization by the appointment of a committee to co-operate with the Commissioner of Agriculture in determining the time of meeting and the business of the next convention, and in forming a plan for a permanent organization.

At the next session of Congress the experiment-station enterprise was again called to the attention of the House of Representatives by the bill which was introduced by William H. Hatch, of Missouri, and referred to the Committee on Agriculture. This committee made a favorable report March 3, 1886, and nearly a year later the bill was passed by Congress, and approved by President Cleveland, March 2, 1887.

According to the official interpretation of the act establishing the stations they were unable to draw the appropriation contemplated in that act until after the passage of a supplementary act, which was approved February 1, 1888. This financial difficulty delayed the establishment of the stations in many of the States. At the present time, however, experiment stations are organized in all the States and in the Territory of Dakota. In several States more than one station has been organized, and in some States there are several

branch stations under one management. Counting these latter as single stations the total number at present is forty-six, but counting the branch stations separately the total number is more than fifty.

The following table shows the number of separate stations and the number of the working force employed in each station, and also the sources and amount of the income which each station receives (as far as these facts have been reported to this office):

Table showing the number of officers composing the Station Staffs of the Agricultural Experiment Stations in the United States, and the revenues of those Stations for the fiscal year ending June 30, 1889, *from the United States under the act of Congress of March* 2, 1887, *from the several States and from other sources.*

State.	Name of station.	No. in staff.	Annual revenue.		
			From what source.	Am't.	Total.
Ala	Agricultural Experiment Station of the Agricultural and Mechanical College of Alabama.	10	Fertilizer fees	$10,000	$23,000
			United States	13,000	
Ala	Canebrake Agricultural Experiment Station	2	State	2,500	4,500
			United States	2,000	
Ark	Arkansas Agricultural Experiment Station	10	...do	15,000	15,000
Cal	Agricultural Experiment Station of University of California.	16	..do	15,000	28,000
			State, etc	13,000	
Col	Agricultural Experiment Station of Colorado.	12	United States	15,000	15,000
Conn	Connecticut Agricultural Experiment Station.	9	State	8,000	18,600
			Analysis fees, etc	3,100	
			United States	7,500	
Conn	Storrs School Agricultural Experiment Station	5	...do	7,500	7,500
Dak	Dakota Agricultural Experiment Station	11	...do	15,000	15,000
Del	Delaware College Agricultural Experiment Station.	5	...do	15,000	15,000
Fla	Agricultural Experiment Station of Florida	......	...do	15,000	15,000
Ga	Georgia Agricultural Experiment Station	7	...do	15,000	15,000
Ill	Agricultural Experiment Station of University of Illinois.	9	...do	15,000	15,000
Ind	Agricultural Experiment Station of Indiana	9	Proceeds of farm	2,000	17,000
			United States	15,000	
Iowa	Iowa Agricultural Experiment Station	11	...do	15,000	15,000
Kans	Kansas Agricultural Experiment Station	12	...do	15,000	15,000
Ky	Kentucky Agricultural Experiment Station	8	..do	15,000	16,500
			Analysis fees, etc	1,500	
La	Sugar Experiment Station No. 1	7	State	2,000	18,400
			Sugar planters	10,000	
			Tax on fertilizers	1,400	
			United States	5,000	
La	State Agricultural Experiment Station No. 2	4	State	2,000	8,400
			Tax on fertilizers	1,400	
			United States	5,000	
La	North Louisiana Experiment Station No. 3	2	State	2,000	12,000
			Ouachita Parish	5,000	
			United States	5,000	
Me	Maine State College Agricultural Experiment Station.	10	...do	15,000	15,000
Md	Maryland Agricultural Experiment Station	6	...do	15,000	15,000
Mass	Hatch Experiment Station of Massachusetts Agricultural College.	8	...do	15,000	15,000
Mass	Massachusetts State Agricultural Experiment Station.	7	State	10,000	10,000
Mich	Experiment Station of Michigan Agricultural College.	18	United States	15,000	15,000
Minn	Agricultural Experiment Station of University of Minnesota.	12	...do	15,000	15,000
Miss	Mississippi Agricultural Experiment Station	10	..do	15,000	15,000
Mo	Missouri Agricultural College Experiment Station.	9	...do	15,000	15,000
Nebr	Agricultural Experiment Station of Nebraska	9	...do	15,000	15,000
Nev	Nevada State Agricultural Station	5	...do	15,000	15,000
N. H	New Hampshire Agricultural Experiment Station.	9	...do	15,000	15,000
N. J	New Jersey State Agricultural Experiment Station.	5	State	11,000	11,000
N. J	New Jersey Agricultural College Experiment Station.	5	United States	15,000	15,000
N. Y	New York Agricultural Experiment Station	7	State	20,000	20,000
N. Y	Cornell University Agricultural Experiment Station.	13	United States	15,000	15,000
N. C	North Carolina Agricultural Experiment Station.	9	State	2,200	17,200
			United States	15,000	

Table showing the number of officers composing the Station Staffs of the Agricultural Experiment Stations in the United States, and the revenues, etc.—Continued.

State.	Name of station.	No. in staff.	Annual revenue.		
			From what source.	Am't.	Total.
Ohio	Ohio Agricultural Experiment Station	7	United States	$15,000	$15,000
Oregon	Oregon Experiment Station	3	...do	15,000	15,000
Pa	Pennsylvania State College Agricultural Experiment Station.	10	State	3,000	18,000
			United States	15,000	
R. I	Rhode Island State Agricultural Experiment Station.	1	...do	15,000	15,000
S. C	South Carolina Agricultural Experiment Station.	13	..do	15,000	20,000
			Tax on fertilizers	5,000	
Tenn	Tennessee Agricultural Experiment Station	7	..do	800	15,800
			United States	15,000	
Tex	Texas Agricultural Experiment Station	11	...do	15,000	15,000
Vt	Vermont State Agricultural Experiment Station.	8	State	3,500	19,500
			Proceeds of farm	1,000	
			United States	15,000	
Va	Virginia Agricultural Experiment Station	5	...do	15,000	15,000
W. Va	West Virginia Experiment Station	5	...do	15,000	15,000
Wis	Agricultural Experiment Station of University of Wisconsin.	8	..do	15,000	20,000
			State	4,000	
			Proceeds of farm	1,000	
	Total	360			710,400
D. C	Office of Experiment Stations				10,000
	Grand total				720,400

A complete report of the financial condition of the stations would undoubtedly increase this amount by several thousand dollars, so that it is safe to say that the total amount which will be expended by the stations during the current year will reach $725,000.

Most of the new stations are in actual operation. Bulletins have been published giving accounts of organization, and of experimental and other work. The investigations cover a wide range of topics, and the stations have in nearly all cases manifested their wisdom by directing their investigations towards the solution of questions of special interest to the localities in which they are situated, without neglecting subjects of more general interest and wider application.

On the 18th of October, 1887, the second convention of Agricultural Colleges and Experiment Stations convened at Washington. A permanent organization was effected, and the association was named "The Association of American Agricultural Colleges and Experiment Stations." George W. Atherton, LL. D., president of the Pennsylvania State College, was elected president of the association. This convention was deeply interested in securing the co-ordination of the work of the several stations and indorsed the action of previous conventions in urging the establishment of a central office to be a medium of intercommunication between the stations. As the result of the efforts of this association, acting in harmony with the Commissioner of Agriculture, such an office was provided for in the annual appropriation bill for the Department of Agriculture for the fiscal year ending June 30, 1889.

Section 3 of the act of March 2, 1887, provides—

That in order to secure, as far as practicable, uniformity of methods and results in the work of said stations, it shall be the duty of the United States Commissioner of Agriculture to furnish forms, as far as practicable, for the tabulation of results of investigation or experiments; to indicate from time to time such lines of inquiry as to him shall seem most important; and, in general, to furnish such advice and assistance as will best promote the purposes of this act. It shall be the duty of each

said station, annually, on or before the 1st day of February, to make to the governor of the State or Territory in which it is located a full and detailed report of its operations, including a statement of receipts and expenditures, a copy of which report shall be sent to each of said stations, to the said Commissioner of Agriculture, and to the Secretary of the Treasury of the United States.

The act of July 18, 1888, appropriates $10,000—

Payable upon the order of the Commissioner of Agriculture, to enable him to carry out the provisions of section 3 of said act of March 2, 1887, and to compare, edit, and publish such of the results of the experiments made under section 2 of said act by said experiment stations as he may deem necessary; and for these purposes the Commissioner of Agriculture is authorized to employ such assistants, clerks, and other persons as he may deem necessary.

To carry out these provisions the Commissioner of Agriculture, as has already been stated, instituted, in October, 1888, an Office of Experiment Stations as a special branch of the Department of Agriculture and appointed a director at its head.

LIST OF AGRICULTURAL EXPERIMENT STATIONS IN THE UNITED STATES.

ALABAMA.

Agricultural Experiment Station of the Agricultural and Mechanical College of Alabama.

Department of the Agricultural and Mechanical College of Alabama.

W. L. Broun, LL. D., President.

Location of station, Auburn. Director, J. S. Newman.
Organized by State June 1, 1883; reorganized April 1, 1888.

Canebrake Agricultural Experiment Station.

Department of Agricultural and Mechanical College of Alabama.

W. L. Broun, LL. D., President.

Location of station, Uniontown. Director, J. S. Newman. Assistant director in charge, W. H. Newman, M. Sc.
Organized by State in 1885.

ARKANSAS.

Arkansas Agricultural Experiment Station.

Department of Arkansas Industrial University.

E. H. Murfee, LL. D., President.

Location of station, Fayetteville. Director, A. E. Menke, D. Sc.
Organized ———, 1888.
Substations at Pine Bluff, Newport, and Texarkana.

CALIFORNIA.

Agricultural Experiment Station of the University of California.

Department of the University of California.

Horace Davis, A. B., President.

Location of station, Berkeley. Director, E. W. Hilgard, Ph. D., LL. D.
Organized by University of California in 1876; reorganized March, 1888.
Substations at Jackson, Amador County; Paso Robles, San Luis Obispo County; and Tulare City.
Grape culture stations at Cupertino, Fresno, and Mission San José.

COLORADO.

Agricultural Experiment Station of Colorado.

Department of the State Agricultural College.

Charles L. Ingersoll, M. S., President.

Location of station, Fort Collins. Director, Charles L. Ingersoll, M. S.
Organized February 21, 1888.
Substations at Del Norte and Rocky Ford.

CONNECTICUT.

The Connecticut Agricultural Experiment Station.

Location of station, New Haven. Director, Samuel W. Johnson, M. A.
Organized by State at Middletown, October 1, 1875; removed to New Haven in 1877; reorganized May 18, 1887.

Storrs School Agricultural Experiment Station.

Department of Storrs Agricultural School.

B. F. Koons, Ph. D., Principal.

Location of station, Storrs, Tolland County. Director, W. O. Atwater, Ph. D.
Organized March 29, 1888.

DAKOTA.

Dakota Agricultural Experiment Station.

Department of Dakota Agricultural College.

Lewis McLouth, Ph. D., President.

Location of station, Brookings. Director, Lewis McLouth, Ph. D.
Organized ———, 1888.

DELAWARE.

The Delaware College Agricultural Experiment Station.

Department of Delaware College.

A. N. Raub, Ph. D., President.

Location of station, Newark. Director, Arthur T. Neale, Ph. D.
Organized May, 1888.

FLORIDA.

Agricultural Experiment Station of Florida.

Department of the Florida State Agricultural and Mechanical College.

F. L. Kern, M. A., President.

Location of station, Lake City. Director, Rev. J. P. De Pass.
Organized ———, 1888.

GEORGIA.

Georgia Agricultural Experiment Station.

Department of State College of Agriculture and Mechanic Arts, University of Georgia.

Rev. William E. Boggs, D. D., Chancellor.

Location of station, Athens. Director, W. L. Jones, M. D.
Organized ———, 1888.

ILLINOIS.

AGRICULTURAL EXPERIMENT STATION OF THE UNIVERSITY OF ILLINOIS.

Department of the University of Illinois.

Selim H. Peabody, Ph. D., LL. D., Regent.

Location of station, Champaign. Director, Selim H. Peabody, Ph. D., LL. D.
Organized April 1, 1888.

INDIANA.

AGRICULTURAL EXPERIMENT STATION OF INDIANA.

Department of Purdue University.

James H. Smart, LL. D., President.

Location of station, La Fayette. Director, Horace E. Stockbridge, Ph. D.
Organized July 1, 1887.

IOWA.

IOWA AGRICULTURAL EXPERIMENT STATION.

Department of Iowa State College of Agriculture and Mechanic Arts.

W. I. Chamberlain, LL. D., President.

Location of station. Ames. Director, R. P. Speer.
Organized February 17, 1888.

KANSAS.

KANSAS AGRICULTURAL EXPERIMENT STATION.

Department of Kansas State Agricultural College.

George T. Fairchild, A. M., President.

Location of station, Manhattan. Director, E. M. Shelton, M. Sc.
Organized February 8, 1888.

KENTUCKY.

KENTUCKY AGRICULTURAL EXPERIMENT STATION.

Department of the Agricultural and Mechanical College of Kentucky.

James K. Patterson, Ph. D., President.

Location of station, Lexington. Director, M. A. Scovell, M. S.
Organized by trustees of college September, 1885; reorganized by State April, 1886; reorganized ———, 1888.

LOUISIANA.

No. 1. SUGAR EXPERIMENT STATION, KENNER.
No. 2. STATE EXPERIMENT STATION, BATON ROUGE.
No. 3. NORTH LOUISIANA EXPERIMENT STATION, CALHOUN.

Department of Louisiana State University and Agricultural and Mechanical College.

Col. J. W. Nicholson, President.

Location of stations: No. 1, Kenner; No. 2, Baton Rouge; No. 3, Calhoun. Director, William C. Stubbs, Ph. D.
No. 1. Organized by Sugar Planters' Association, October, 1885.
No. 2. Organized by State Bureau of Agriculture, January, 1886.
No. 3. Organized April, 1888.

MAINE.

MAINE STATE COLLEGE AGRICULTURAL EXPERIMENT STATION.

Department of State College of Agriculture and the Mechanic Arts.

Merritt C. Fernald, Ph. D., President.

Location of station, Orono. Director, Whitman H. Jordan, M. S.
Organized by State March 3, 1885; reorganized October 1, 1887.

MARYLAND.

MARYLAND AGRICULTURAL EXPERIMENT STATION.

Department of Maryland Agricultural College.

Henry E. Alvord, C. E., President.

Location of station, Agricultural College P. O. Director, Henry E. Alvord, C. E.
Organized March 9, 1888.

MASSACHUSETTS.

MASSACHUSETTS STATE AGRICULTURAL EXPERIMENT STATION.

Location of station, Amherst. Director, Charles A. Goessmann, Ph. D.
Organized by State July, 1882; reorganized March, 1888.

HATCH EXPERIMENT STATION OF THE MASSACHUSETTS AGRICULTURAL COLLEGE.

Department of the Massachusetts Agricultural College.

Henry H. Goodell, M. A., President.

Location of station, Amherst. Director, Henry H. Goodell, M. A.
Organized March 2, 1888.

MICHIGAN.

EXPERIMENT STATION OF MICHIGAN AGRICULTURAL COLLEGE.

Department of Michigan Agricultural College

Edwin Willits, M. A., President.

Location of station, Agricultural College. Director, Edwin Willits, M. A.
Organized February 21, 1888.

MINNESOTA.

AGRICULTURAL EXPERIMENT STATION OF THE UNIVERSITY OF MINNESOTA.

Department of the University of Minnesota.

Cyrus Northrop, LL. D., President.

Location of station, St. Anthony Park. Director, Edward D. Porter, Ph. D.
Organized ———, 1888.

MISSISSIPPI.

MISSISSIPPI AGRICULTURAL EXPERIMENT STATION.

Department of Mississippi State Agricultural College.

General S. D. Lee, President.

Location of station, Agricultural College. Director, S. M. Tracy, M. S.
Organized February 1, 1888.

MISSOURI.

Missouri Agricultural Experiment Station.

Department of Missouri Agricultural College.

J. W. Sanborn, B. S., Dean.

Location of station, Columbia. Director, J. W. Sanborn, B. S.
Organized January 2, 1888.

NEBRASKA.

Agricultural Experiment Station of Nebraska.

Department of University of Nebraska.

Irving J. Manatt, Ph. D., LL. D., Chancellor.

Location of station, Lincoln. Director, Charles E. Bessey, Ph. D.
Organized July 1, 1887.

NEVADA.

Nevada State Agricultural Station.

Department of Nevada State University.

LeRoy D. Brown, Ph. D., President.

Location of station, Reno. Director, LeRoy D. Brown, Ph. D.
Organized January 2, 1888.

NEW HAMPSHIRE.

New Hampshire Agricultural Experiment Station.

Department of New Hampshire College of Agriculture and the Mechanic Arts.

Charles H. Pettee, C. E., Dean.

Location of station, Hanover. Director, G. H. Whitcher, B. S.
Organized ———, 1888.

NEW JERSEY.

New Jersey State Agricultural Experiment Station.

Location of station (at Rutgers College), New Brunswick. Director, George H. Cook, LL. D.
Organized by State March 18, 1880.

New Jersey Agricultural College Experiment Station.

Department of Rutgers College.

Merrill Edwards Gates, Ph. D., LL. D., L. H. D., President.

Location of station, New Brunswick. Director, George H. Cook, LL. D.
Organized ———, 1888.

NEW YORK.

New York Agricultural Experiment Station.

Location of station, Geneva. Director, Peter Collier, Ph. D.
Organized by State March 1, 1882.

Cornell University Agricultural Experiment Station.

Department of Cornell University.

Charles K. Adams, LL. D., President.

Location of station, Ithaca. Director, Isaac Phillips Roberts, M. Agr.
Organized by Faculty of Agriculture February, 1879; reorganized October 26, 1887.

NORTH CAROLINA.

North Carolina Agricultural Experiment Station.

Location of station, Raleigh. Director, H. B. Battle, Ph. D.
Organized by State March 12, 1877; reorganized ——, 1887.

OHIO.

Ohio Agricultural Experiment Station.

Location of station, Columbus. Director, Charles E. Thorne.
Organized by State April 25, 1882; reorganized April 2, 1888.

OREGON.

Oregon Experiment Station.

Department of Oregon State Agricultural College.

B. L. Arnold, A. M., President.

Location of station, Corvallis. Director, E. Grimm, B. Sc.
Organized March, 1888.

PENNSYLVANIA.

The Pennsylvania State College Agricultural Experiment Station.

Department of the Pennsylvania State College.

George W. Atherton, LL. D., President.

Location of station, State College, Centre County. Director, H. P. Armsby, Ph. D.
Organized June 30, 1887.

RHODE ISLAND.

Rhode Island State Agricultural Experiment Station.

Department of Rhode Island State Agricultural School.

Charles O. Flagg, B. S., President Board of Managers.

Location of station, Kingston. Director *pro tem.*, Charles O. Flagg, B. S.
Organized March 23, 1888.

SOUTH CAROLINA.

South Carolina Agricultural Experiment Station.

Department of the University of South Carolina.

John M. McBryde, Ph. D., LL. D., President.

Location of station, Columbia. Director, John M. McBryde, Ph. D., LL. D.
Organized January, 1888; consolidated in March, 1888, with station established by State in September, 1887.

TENNESSEE.

Tennessee Agricultural Experiment Station.

Department of the University of Tennessee.

Charles W. Dabney, jr., Ph. D., President.

Location of station, Knoxville. Director, Charles W. Dabney, jr., Ph. D.
Organized by trustees of the University June 8, 1882; reorganized, 1887.

TEXAS.

Texas Agricultural Experiment Station.

Department of Agricultural and Mechanical College of Texas.

L. L. McInnis, M. A., Chairman of Faculty.

Location of station, College Station. Director, F. A. Gulley, M. Sc.
Organized January 25, 1888.

VERMONT.

Vermont State Agricultural Experiment Station.

Department of University of Vermont.

Matthew Henry Buckham, D. D., President.

Location of station, Burlington. Director, W. W. Cooke, M. A.
Organized by State December, 1886.

VIRGINIA.

Virginia Agricultural Experiment Station.

Department of Virginia Agricultural and Mechanical College.

L. L. Lomax, President.

Location of station, Blacksburg. Director, William Ballard Preston.
Organized in May, 1888.

WEST VIRGINIA.

West Virginia Experiment Station.

Department of West Virginia University.

E. M. Turner, LL. D., President.

Location of station, Morgantown. Director, John A. Myers, A. M.
Organized ———, 1888.

WISCONSIN.

Agricultural Experiment Station of the University of Wisconsin.

Department of University of Wisconsin.

T. C. Chamberlin, LL. D., President.

Location of station, Madison. Director, W. A. Henry, B. Agr.
Organized by State October 1, 1883; reorganized ———, 1888.

LIST OF AGRICULTURAL COLLEGES IN THE UNITED STATES.

ALABAMA.

Agricultural and Mechanical College.

Alabama Polytechnic Institute.

Location, Auburn. President, William Le Roy Broun, M. A., LL. D.
Organized by State March, 1872.

ARKANSAS.

Arkansas Industrial University.

Location, Fayetteville. President, Edward Hunter Murfee, A. M., LL. D.
Organized by State March 27, 1871.

CALIFORNIA.

College of Agriculture of the University of California.

Location, Berkeley. President, Horace Davis, A. B.
Dean, Irving Stringham, Ph. D.
Organized by State March 23, 1868.

COLORADO.

State Agricultural College of Colorado.

Location, Fort Collins. President, Charles L. Ingersoll, M. S.
Organized by State March, 1877.

CONNECTICUT.

Sheffield Scientific School of Yale University.

Location, New Haven. President, Timothy Dwight, D. D., LL. D.
Director, George J. Brush, LL. D.
Organized in 1847; reorganized in 1860.

Storrs Agricultural School.

Location, Mansfield. Principal, B. F. Koons, A. M., Ph. D.
Organized by State in 1881.

DAKOTA.

Dakota Agricultural College.

Location, Brookings. President, Lewis McLouth, A. M., Ph. D.
Organized by State in 1884.

DELAWARE.

Delaware College.

Location, Newark. President, Albert N. Raub, A. M., Ph. D.
Organized by State in 1834; reorganized in 1851 and 1871.

FLORIDA.

Florida State Agricultural and Mechanical College.

Location, Lake City. President, F. L. Kern.
Organized by State in 1884.

GEORGIA.

Georgia State College of Agriculture and Mechanic Arts of the University of Georgia.

Location, Athens. Chancellor, William E. Boggs, D. D.
Organized in 1872.

Southwest Georgia Agricultural College.

Location, Cuthbert. President, Benjamin T. Hunter, A. M.
Organized in 1879.

North Georgia Agricultural College.

Location, Dahlonega. President, William S. Basinger, A. M.
Organized in 1873.

Middle Georgia Military and Agricultural College.

Location, Milledgeville. President, D. H. Hill, LL. D.
Organized in 1880.

South Georgia Agricultural College.

Location, Thomasville. President, G. M. Lovejoy.
Organized in 1879.

ILLINOIS.

College of Agriculture of the University of Illinois.

Location, Urbana. Regent, Selim H. Peabody, Ph. D., LL. D.
Dean, George E. Morrow, A. M.
Organized by State February, 1867.

INDIANA.

The School of Agriculture, Horticulture, and Veterinary Science of Purdue University.

Location, La Fayette. President, James H. Smart, LL. D.
Organized by State August 26, 1873.

IOWA.

Iowa State College of Agriculture and Mechanic Arts.

Location, Ames. President, W. I. Chamberlain, LL. D.
Organized by State in 1858; opened for students October 21, 1868.

KANSAS.

Kansas State Agricultural College.

Location, Manhattan. President, George T. Fairchild, A. M.
Organized by State March 3, 1863.

KENTUCKY.

Agricultural and Mechanical College of Kentucky.

Location, Lexington. President, James K. Patterson, Ph. D
Organized by State in 1865; reorganized in 1880.

LOUISIANA.

Louisiana State University and Agricultural and Mechanical College.

Location, Baton Rouge. President, J. W. Nicholson, A. M.
Organized by State April 7, 1873; reorganized January 2, 1877.

MAINE.

Maine State College of Agriculture and the Mechanic Arts.

Location, Orono. President, Merritt C. Fernald, A. M., Ph. D.
Organized by State in 1865.

MARYLAND.

Maryland Agricultural College.

Location, Agricultural College. President, Henry E. Alvord, C. E.
Organized by State in 1856.

MASSACHUSETTS.

Massachusetts Agricultural College.

Location, Amherst. President, Henry H. Goodell, M. A.
Organized by State in 1863; opened for students in 1867.

Bussey Institution of Harvard University.

Location, Jamaica Plain. President, Charles W. Eliot, LL. D.
Dean, F. H. Storer.
Organized in 1870 by President and Fellows of Harvard University.

MICHIGAN.

Michigan Agricultural College.

Location, Agricultural College. President, Edwin Willits, LL. D.
Organized by State February 12, 1855.

MINNESOTA.

College of Agriculture of the University of Minnesota.

Location, St. Anthony Park. President, Cyrus Northrop, LL. D.
Organized in 1868.

State School of Agriculture of the University of Minnesota.

Location, St. Anthony Park. President, W. W. Pendergast.
Organized by Board of Regents in 1888.

MISSISSIPPI.

Agricultural and Mechanical College of Mississippi.

Location, Agricultural College. President, S. D. Lee.
Organized by State October, 1880.

Alcorn Agricultural and Mechanical College.

Location, Rodney. President, John H. Burrus, M. A.
Organized by State in 1871; reorganized in 1878.

MISSOURI.

Agricultural and Mechanical College of the University of Missouri.

Location, Columbia. Dean, J. W. Sanborn, B. S.
Organized by State in 1870.

NEBRASKA.

Industrial College of the University of Nebraska.

Location, Lincoln. Chancellor, Irving J. Manatt, Ph. D., LL. D.
Dean, Charles E. Bessey, Ph. D.
Organized by State February 15, 1869; opened for students September 7, 1871.

NEVADA.

School of Agriculture of the Nevada State University.

Location, Reno. President, LeRoy D. Brown, A. M., Ph. D.
Organized by State in 1887.

NEW HAMPSHIRE.

New Hampshire College of Agriculture and the Mechanic Arts, in connection with Dartmouth College.

Location, Hanover. President, Samuel C. Bartlett, D. D., LL. D.
Dean, Charles H. Pettee, A. M., C. E.
Organized by State in 1866.

NEW JERSEY.

Rutgers Scientific School of Rutgers College.

Location, New Brunswick. President, Merrill Edward Gates, Ph. D., LL. D., L. H. D.
Made State College of Agriculture and the Mechanic Arts April 4, 1864.

NEW YORK.

College of Agriculture of Cornell University.

Location, Ithaca. President, Charles Kendall Adams, LL. D.
University organized by State April 27, 1865.
College organized by trustees of University, June 20, 1888.

NORTH CAROLINA

College of Agriculture and the Mechanic Arts of the University of North Carolina.

Location, Chapel Hill. President, Kemp P. Battle, LL. D.
Organized ———.

OHIO.

Ohio State University.

Location, Columbus. President, William H. Scott, LL. D.
Organized by State September 17, 1873.

OREGON.

Oregon State Agricultural College.

Location, Corvallis. President, B. L. Arnold, A. M.
Organized ———.

PENNSYLVANIA.

Pennsylvania State College.

Location, State College. President, George W. Atherton, LL. D.
Organized in 1859; reorganized in 1862 and 1874.

RHODE ISLAND.

Agricultural and Scientific Department of Brown University.

Location, Providence. President, E. G. Robinson, D. D., LL. D.
Organized ———.

Rhode Island State Agricultural School.

Location, Kingston, President of Board of Managers, Charles O. Flagg, B. S.
Organized in 1888.

SOUTH CAROLINA.

College of Agriculture and Mechanic Arts of the University of South Carolina.

Location, Columbia. President, John M. McBryde, Ph. D., LL. D.
Organized in 1879.

Claflin University, College of Agriculture and Mechanics' Institute.

Location, Orangeburg. President, L. M. Dunton, D. D.
Organized March 12, 1872.

TENNESSEE.

State Agricultural and Mechanical College of the University of Tennessee.

Location, Knoxville. President, Charles W. Dabney, jr., Ph. D.
Dean, Thomas W. Jordan, A. M.
Organized in 1869.

TEXAS.

Agricultural and Mechanical College of Texas.

Location, College Station. Chairman of College Faculty, Lewis L. McInnis, LL. D. Organized April 17, 1871.

VERMONT.

University of Vermont and State Agricultural College.

Location, Burlington. President, Matthew H. Buckham, D. D.
College organized November 9, 1865.

VIRGINIA.

Virginia Agricultural and Mechanical College.

Location, Blacksburg. President, L. L. Lomax.
Organized in 1872.

Hampton Normal and Agricultural Institute.

Location, Hampton. President, S. C. Armstrong.
Organized by American Missionary Society April, 1868; reorganized under charter from State June, 1870.

WEST VIRGINIA.

West Virginia University.

Location, Morgantown. President, E. M. Turner, LL. D.
Organized February 2, 1867.

WISCONSIN.

Department of Agriculture of the University of Wisconsin.

Location, Madison. President, T. C. Chamberlin, LL. D.
University organized in 1848.

REPORT OF THE MICROSCOPIST.

SIR: I have the honor to submit herewith my seventeenth annual report.

During the past year a large portion of the time of my Division has been given to the preparation of exhibits for the expositions at Cincinnati, Ohio, and Paris, France. Very superior collections of fibers, foreign and domestic, have been made, and a large correspondence has been carried on relating to fibers and to the latest methods of preparing them for general purposes. Four samples of flax, consisting of a sample each of French (Courtrai), $380 per ton; Dutch (Holland), $325 per ton; Irish, $275 per ton, and Russian, $200 per ton, have been received, each having interesting distinctive characteristics.

The adulteration of food-stuffs, principally of condiments, has received special attention, and samples from various quarters have been examined, and, in many cases, adulterations detected.

In making microscopic investigations of condiments, such as peppers, mustards, cloves, allspice, and cinnamon, for the purpose of ascertaining the peculiarities of their cell-structure, I find it necessary to soften the berry or roots, as the case may be, in water for a period of about twenty-four hours, so that they may be cut in sections sufficiently thin and of various grades of thickness, at various angles, without which the physical and structural characteristics of the cells of the respective layers could not be observed by the aid of the microscope. For this purpose the respective layers should be viewed by plain and polarized light. For example, on subjecting the epidermal layer of white mustard seed to polarized light I have discovered that every cell composing it is not only a polarizing body, but each of these cells very unexpectedly shows a well-defined cross, resembling the appearance of starch in some respects, a feature, I believe, not heretofore observed; but for this discovery such bodies might be mistaken for an adulterant, since the condiment mustard is wholly destitute of starch, oil taking its place, a fact acknowledged by all experts.

Plates I, II, III, IV, V, and VI represent sections of the condiments under consideration.

Ground olive-stones and cocoa-nut shells, said to be largely used in adulterating some condiments, are composed mostly of a class of cells known as sclerenchyma cells. When powdered these substances resemble white pepper so closely that only by the use of the microscope can their presence be detected when combined with pepper, black or white. These substances have neither taste nor smell. Powdered olive-stones and cocoa-nut shells may be purchased cheaply in large quantities. The poorer classes, who generally buy the lowest-priced articles, are the greatest sufferers, since they pay a high price for these worthless adulterants. Stringent legislation

is required to prevent their use. One of the largest olive-growers of California, with whom I have had correspondence on the subject, informs me that olive-stones are collected and sold for the purpose of adulterating condiments.

In making these investigations I have held it to be of the first importance to photograph the sections of the condiments, and, by means of the camera lucida, make exact drawings of such parts as are necessary. My next step is to reduce the condiment to powder and observe its appearance under high and low powers of the microscope, comparing it with the sample bought in open market. Such comparisons reveal a marked difference in some of the samples purchased. Many observations are made in order to ascertain whether more than one adulterant is used and whether a foreign substance observed is present by accident, or in such quantity as to prove its fraudulent character. For legislative or judicial purposes it is not of so much importance to ascertain what precise adulterant is used, provided it be harmless, as it is to ascertain how much is used, as this determines whether the material has been added with fraudulent intent. Experts allow but 1 per cent. for accidental adulteration.

BLACK PEPPER.

Plate I, Fig. 1 represents a longitudinal section of a berry of black pepper. Fig. 2 represents its starch cells, most of which contain starch granules. They are best observed by treatment with weak solutions of dilute sulphuric acid and iodine, which stains them blue. Fig. 3 represents oil cells. The iodine mixture, although staining the starch cells and granules blue, has the property of coloring the oil cells yellow, and a narrow band within the cortical layer becomes of a reddish color. The dark cortical layer is not affected materially by the staining fluid. This layer is composed largely of sclerenchyma or "stone" cells; these exhibit under polarized light, with or without selenite, the prismatic colors. In the dark-brown cortical layer, when cut sufficiently thin to be semi-transparent, numerous spicules are observed of a composition similar to, if not identical with, that of the sclerenchyma cells, and like them polarizing. Were not these spicules particularized, their presence in pure ground pepper might be mistaken for a new adulterant. I am not aware that these spicules have been observed hitherto. They are best seen with powers of about 500 diameters. Fig. 4 represents the appearance of pure ground black pepper in which these spicules singly and combined appear as well as starch cells, oil cells, and fragments of the dark-brown cortical layer, the latter showing the presence of polarizing "stone" cells common to all cortical substances, differing, however, in size and form in different substances. Fig. 5 exhibits the appearance of adulterated ground black pepper. The large yellow bodies in the center represent the adulterants commonly used in white and black pepper, consisting in this instance of the sclerenchyma cells of olive-stone powder. A represents groups of the sclerenchyma cells seen in ground cocoa-nut shells, mentioned above as one of the adulterants used in this condiment. The cells of the inner surface of the cocoa-nut shell are light colored and spindle-shaped, while those of the body of the shell are dark colored, yellowish brown or yellow tinged with brown. B represents individual cells of powdered olive-stone. These cells measure about one-thousandth of an inch in diameter.

WHITE PEPPER.

White pepper is made from the black-pepper berry. It is said that the pepper berries are softened in water and subjected to friction to remove the cortical layer, which is very thin. When dry they are ground to a fine powder. The interior of the berry consists, as has been shown, mostly of oil cells, starch cells, and very minute starch granules. Small portions of the dark cortical layer, however, are frequently observed in reasonably pure white pepper. It is reported that the black washings of the berry are by some dealers carefully dried, ground, and mixed with ground black pepper. Pepper experts may be able to detect this adulteration with the naked eye, owing to the unusual amount of black color thus added. Pure black pepper is necessarily of a much lighter color than a pepper with which the ground dark hulls have been mixed. In the case of white pepper adulterated with the powder of olive-stones, detection is not so easy, since to the naked eye there is a very close resemblance between the genuine article and the adulterant. It is observed that the introduction of the powder of olive-stones greatly diminishes the odor of both white and black pepper if used in large quantities; and since the powder of olive-stones has a greater specific gravity than the powder of ground black pepper, the latter, by measurement, would occupy more space than the former, weight for weight, though I am not aware that their relative weight to measurement has been exactly determined. The structural forms of the pepper berry are very varied, beautiful, and well defined. The microscopic test is considered by all European authorities on the subject of food adulteration the most reliable.

WHITE MUSTARD SEED.

The structural character of white mustard seed is very varied and interesting, but differs materially in its cell-arrangement from that of the black-pepper berry. Plate II, Fig. 1, represents the natural size of the seed. If steeped in cold water for a period of about thirty-six hours at a temperature of 75° Fahr., the external surface of the seed becomes highly glutinous. If a portion of this glutinous substance is removed and viewed in the usual way under powers of about 250 diameters it appears cellular, and consists in fact of the epidermal tissue and a gum.

The cellular structure of the epidermis has been described by Hassal in his volume on Food Adulterations, but he seems not to have observed the fact that each cell when subjected to polarized light exhibits a cross already alluded to. This tissue is quite transparent. Its form is represented by Fig. 3, Plate II.

In the center of each cell, according to Hassal, there is a tube which communicates with the underlying layer of cells. *a* represents a more highly magnified view of the so-called tubes. Proceeding from each of these, appear, as shown in Fig. 3, thread-like filaments of great length. Hassal's drawings fail to show these. I think it probable from the extraordinary length and fineness of these filaments that they consist simply of the gummy substance of the epidermal layer. I find these filaments soluble in nitric acid, while the cellular tissue is not injured by its application. Fig. 4, at first sight, seems to consist of two layers, but on subjecting it to slight pressure between two pieces of glass the surface becomes flat. If Fig. 4 really consists of two layers, Fig. 5 represents the under layer, and below it is

found a layer of cells as in Fig. 6, a layer not described by Hassal. Fig. 7 represents a cellular layer, composed for the most part of oil cells. Under high powers they seem to contain very minute starch granules, but, as Hassal has stated, are not stained by a solution of sulphuric acid and iodine. I find that under the action of this solution the cells appear quickly filled with large globules of oil, the sulphuric acid causing a union of the minute oil globules.

Under powers of 500 diameters the oil globules are well defined as seen in Fig. 8. Within these globules are to be observed very minute granules no larger than those observed in the red blood-corpuscles of the human body. Within this layer of oil cells the plantlet is embedded (see 2, Fig. 9). *b* represents the forms of the spiral vessels observed. If the lobes of the plantlet (2) were folded one upon the other it would appear as found in the seed. Fig. 10 represents the appearance of pure ground mustard under the microscope. Fig. 11 represents polarizing bodies as seen by polarized light and blue selenite. From the fact that starch granules have never been observed in pure ground mustard nor in dissections of the seed, it follows that if any description of starch is found in the mustard of commerce it must be an adulteration. I have a sample of mustard, entirely free from starch or other adulteration, procured from a dealer in drugs of this city. I am informed by a Washington merchant that he can obtain perfectly pure mustard from those who make it their business to grind condiments by simply paying the price demanded for it; but the poor demand cheap goods, hence generally two and sometimes three qualities of condiments are on the market, the highest-priced being really the cheapest article.

Pure, best English mustard is sold by druggists at 50 cents per pound, retail. If adulterated with 50 per cent. of flour, worth 5 cents per pound, and sold at the same price, it is manifest that the poor pay for flour used as an adulterant in this condiment at the rate of 50 cents per pound.

BLACK MUSTARD SEED.

Plate III represents a dissection of black mustard seed. Fig. 1 is a general view of the seed as sold. Fig. 2, the epidermal layer. Fig. 3, the second layer. Fig. 4, third layer. Fig. 5, a layer of cells similar to that discovered in white mustard seed (see Fig. 6, Plate II). This layer is also found over and in contact with the oil cells (Fig. 6). By the use of sulphuric acid applied to the surface of the oil cells, minute globules of oil, scarcely observable, even by high powers, combine one with another, forming large globules, some of them large enough to fill the entire cell. Fig. 7 represents pure ground black mustard seed. Fig. 8 represents the same adulterated, showing the presence of starch, which is not found in pure black mustard.

CLOVES.

Plate IV, Fig. 1, represents a section of cloves, through the ovules, or rather through a point where the ovules would be in the mature seed. I am informed, on good authority, that cloves are the unripe buds of the plant, and that it has been found necessary to pluck the buds in the unripe state for commercial reasons. On subjecting a very thin section of cloves to polarized light it is found to be very full of "stone" cells. Longitudinal sections of clove buds are very much longer in proportion to their diameter than sections of the

pepper berry. Fig. 2 represents their general appearance under polarized light and selenite. In this case the sclerenchyma cells are magnified about 225 diameters. The section itself is represented under very low powers.

ALLSPICE.

Plate V, Fig. 1, represents a sectional view of a berry of allspice, natural size, as seen when cut through its center showing its ovules. Fig. 2 represents a highly magnified view of the same, transferred from a photograph of a thin section, showing the ovules or seed proper. The blue portion of the section represents the starch in the ovule, the brown cellular portion, the nitrogenous matter, the outer or ocherous portion, the shell, husk, or cortex studded with "stone" or sclerenchyma cells. Figs. 3 and 4 represent the appearance of pure ground allspice.

CINNAMON.

Plate V represents the structural character of cinnamon. Under polarized light it appears a beautiful object. Fig. 1 represents large tubular cells, spiral ducts, etc. Fig. 2 represents a longitudinal section of the bark, consisting largely of "stone" cells. Fig. 3, a cross-section view of the tubular cells, spiral ducts, etc. These spindle-shaped cells are highly polarizing bodies. Fig. 4 represents individual sclerenchyma cells which contain starch × 500.

COLOR-REACTIONS OF FATS AND OILS, AND FLUORESCENCE.

Plate VII, Figs. 1 to 10, inclusive, represents the color-reactions of fats and oils produced by treatment with a solution of dilute sulphuric acid, specific gravity 1.705. Chemically-pure sulphuric acid, combined in the proportion of 90 parts of the acid to 30 parts of distilled water, will give nearly the above specific gravity. If about 100 grains of this solution at 75° F. (23.89° C.) is combined with 400 grains of any of the fats or oils, and mixed quickly and intimately in a porcelain vessel, a color-reaction takes place. To observe further results of the treatment with the acid solution, pour the mixture into a test-tube, when further changes are obtained. The dilute acid falls to the bottom of the tube, together with certain products of the treated fat; the undissolved fat floats on top. Under these circumstances the phenomenon of fluorescence referred to in a former report becomes apparent in such oils and fats as are known to possess this property. For further particulars on this subject see pages 622 and 623, U. S. Agricultural Report, 1887.

Fig. 1 represents palmitic acid under the color-reaction test as described above. Fig. 2 represents palmitin treated in like manner. Fig. 3 represents the color-reaction of stearic acid. Fig. 4, commercial stearine. Fig. 5, oleic acid.* The fluorescence in this case is best observed by holding the test-tube in a side light slightly in the shade and against a dark background. If held towards the light it will appear of an amber color. Fig. 6 represents the color-reaction test applied to Benne oil. Figs. 7, 8, 9, and 10 represent olive oil, cotton-seed oil, peanut oil, and "oleo," respectively, treated in like manner.

Plate VIII. Beef-fat dripping, similarly treated, gives, at first, the reaction represented in Fig. 1, changing as seen in Fig. 2, and after the lapse of several days appears as seen in Fig. 3. The fat of the domestic cat turns first to a well-defined lilac color, then darker, and ultimately to a vandyke brown.

* Since making the above experiment with oleic acid, I find with a purer sample there is but a very slight fluorescence.

The fat of the wild-cat gives a similar reaction (see Figs. 9 and 10). The fat of the deer passes through three stages, represented in Figs. 6, 7, and 8.

Plate IX represents the color-reactions of butter under the sulphuric-acid test. At first, butter assumes a pinkish tint under this treatment, quickly turning to yellow (see Figs. 1 and 2), and again changing as represented in Figs. 3, 4, and 5. Some grades of pure butter, free from any added coloring matter, change first to green, then quickly to lilac, especially if old butters (see Figs. 6, 7, 8, 9, and 10).

These results of my experiments on the color-reactions of fats are, so far as I am aware, entirely new, and will serve a good purpose hereafter as another method of testing the purity of oils and fats. The nature of the fluorescent compounds produced, seen in the lower portion of the test-tubes, has not yet been chemically examined. It should be understood that in such experiments the oils or fats used, should be fresh.

A NEW POCKET POLARISCOPE.

(Oleomargariscope.)

In the course of my experience as an expert witness in prosecutions for violations of the butter laws of the District of Columbia I found it desirable to have a simpler form of microscopic or polariscopic combination than the cumbrous stand with polariscope in general use, since all the parties interested, judge, jury, and attorneys, desired to see for themselves the crystalline forms of the fatty compounds known as oleomargarine. To this end I constructed the instrument illustrated in the accompanying plate.

Fig. 1 represents the general appearance of the pocket polariscope when not in use.

Fig. 2 represents a sectional drawing showing its interior arrangement.

(*a*) Eye-piece such as is ordinarily used.

(*b*) Objective one-half inch, of the usual construction.

(*m*) Analyzer, or Nicol prism.

(*n*) Polarizer, firmly secured in tube (*c*), which may be rotated as desired, thereby changing the prismatic colors.

(*d*) Two disks of thin plate-glass, between which a small portion of butter or oleomargarine is placed, secured in position by ring (*f*).

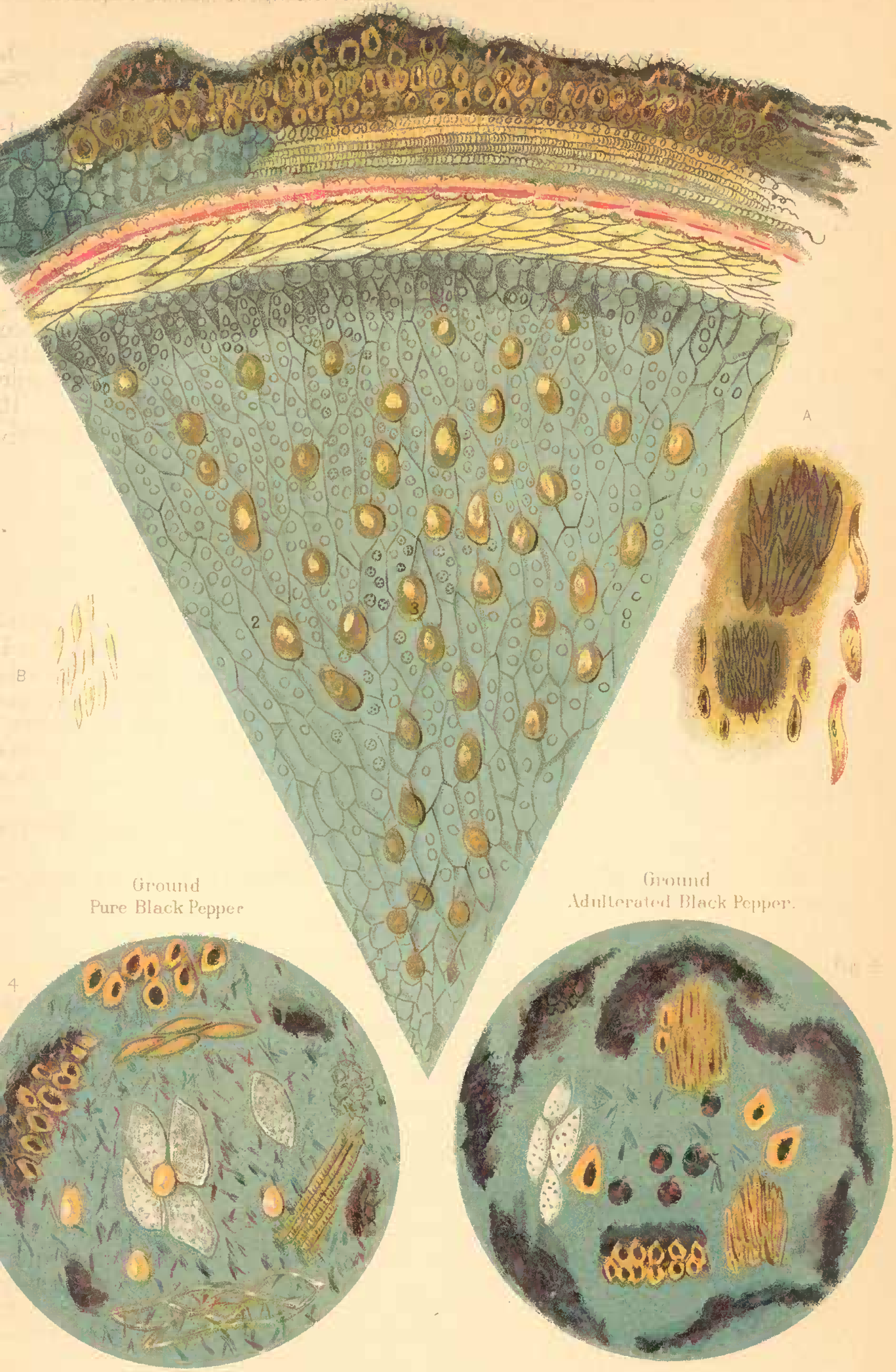
(*e*) Disk of selenite, held in position by ring (*g*).

(*h*) Lens, for the double purpose of illuminating the polarizer and protecting it from dust. A lens is also placed over the polarizer (*n*), which concentrates the light on the butter or other fat to be examined.

It will be seen from the drawing that the objective is readily focused by means of the draw-tube (*i*). Hold the object up to a strong light; if the butter is pure, and free from adulteration, an even green, or red color, only, will be observed, depending upon the character of the selenite used. If "oleo" or lard is used, a fine display of prismatic colors will be observed.

THOMAS TAYLOR,
Microscopist.

HON. NORMAN J. COLMAN,
Commissioner.



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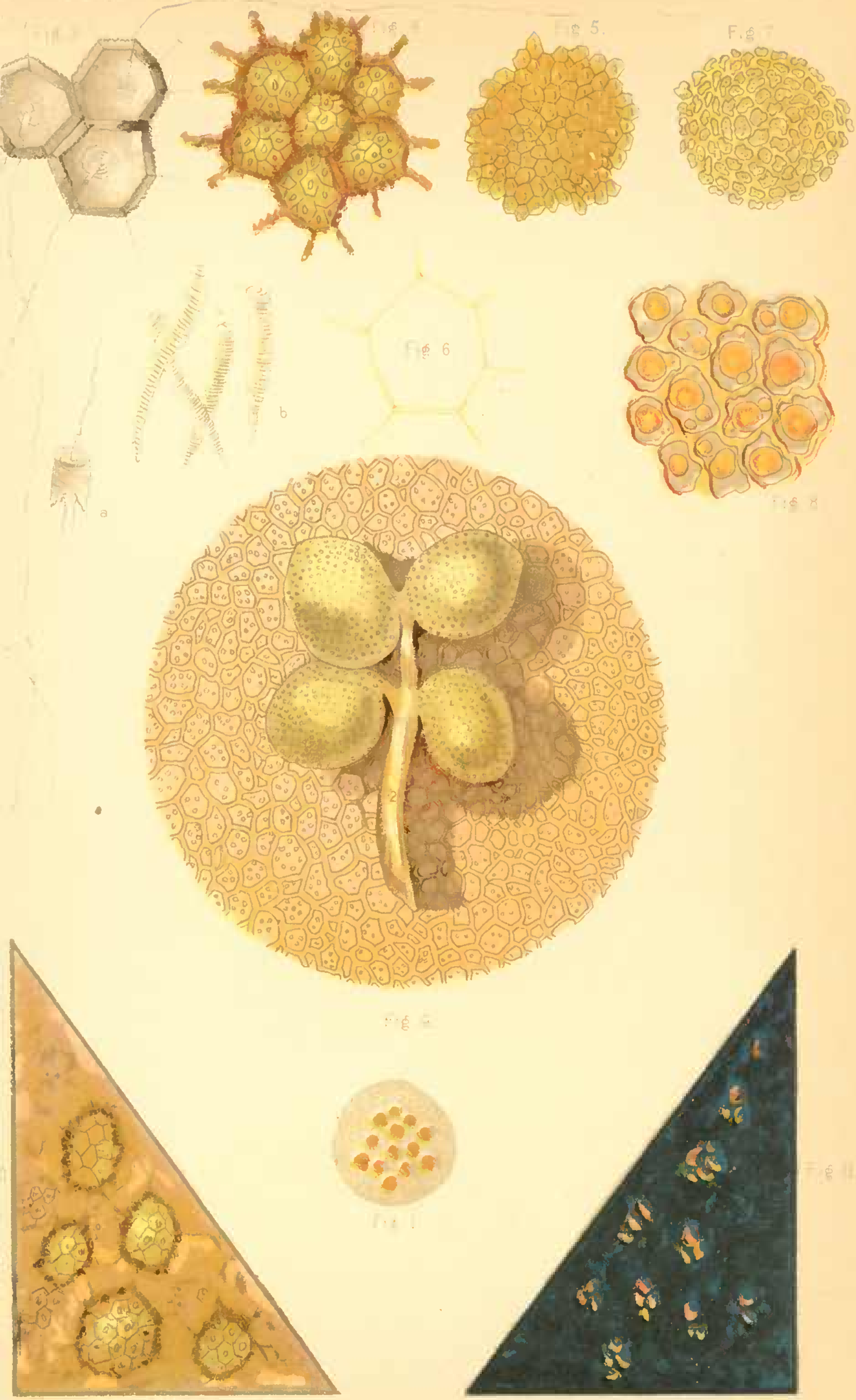
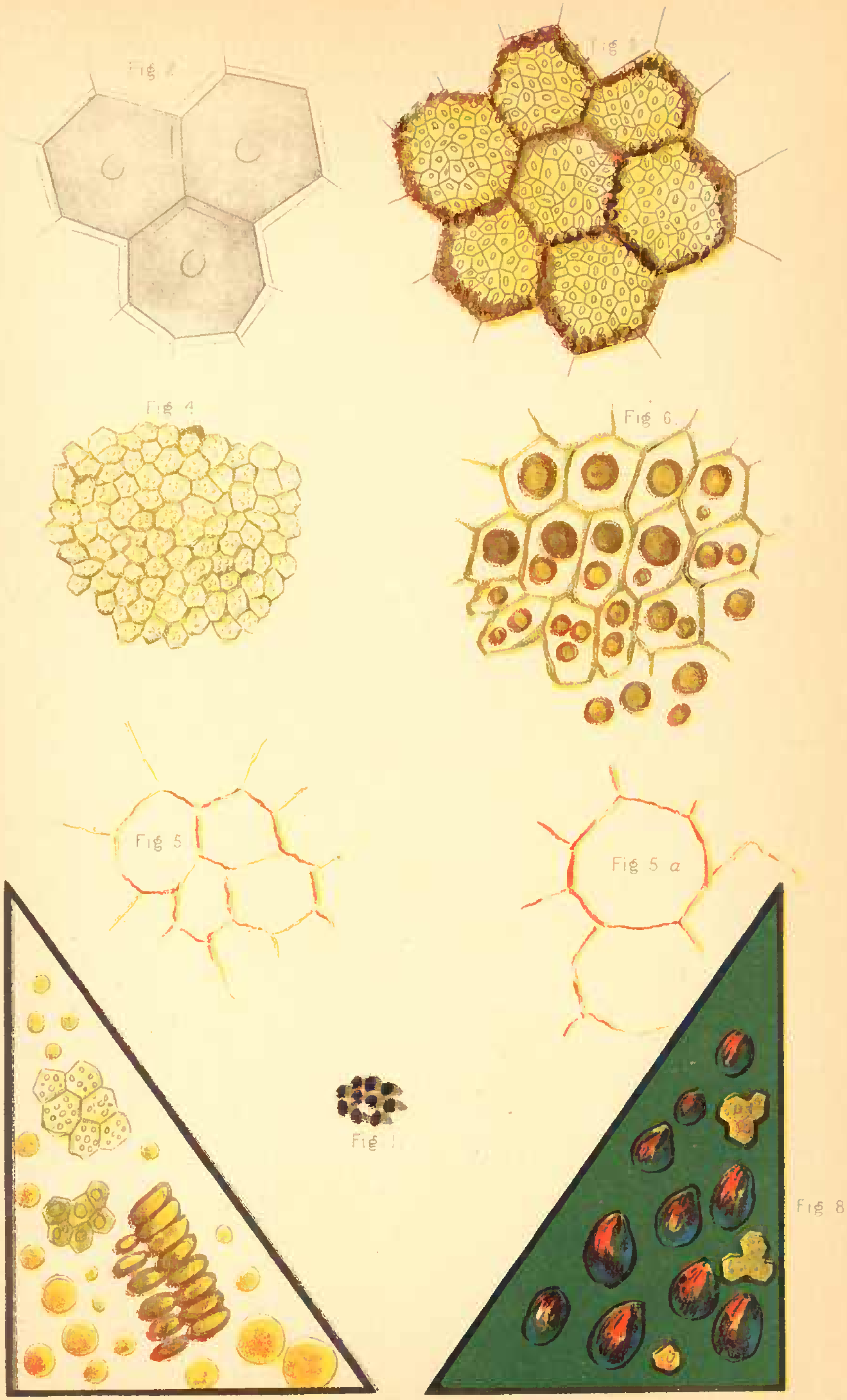
Geo S Harris & Sons, Lith. Phila.

LONGITUDINAL SECTION OF BLACK PEPPER BERRY.



WHITE MUSTARD

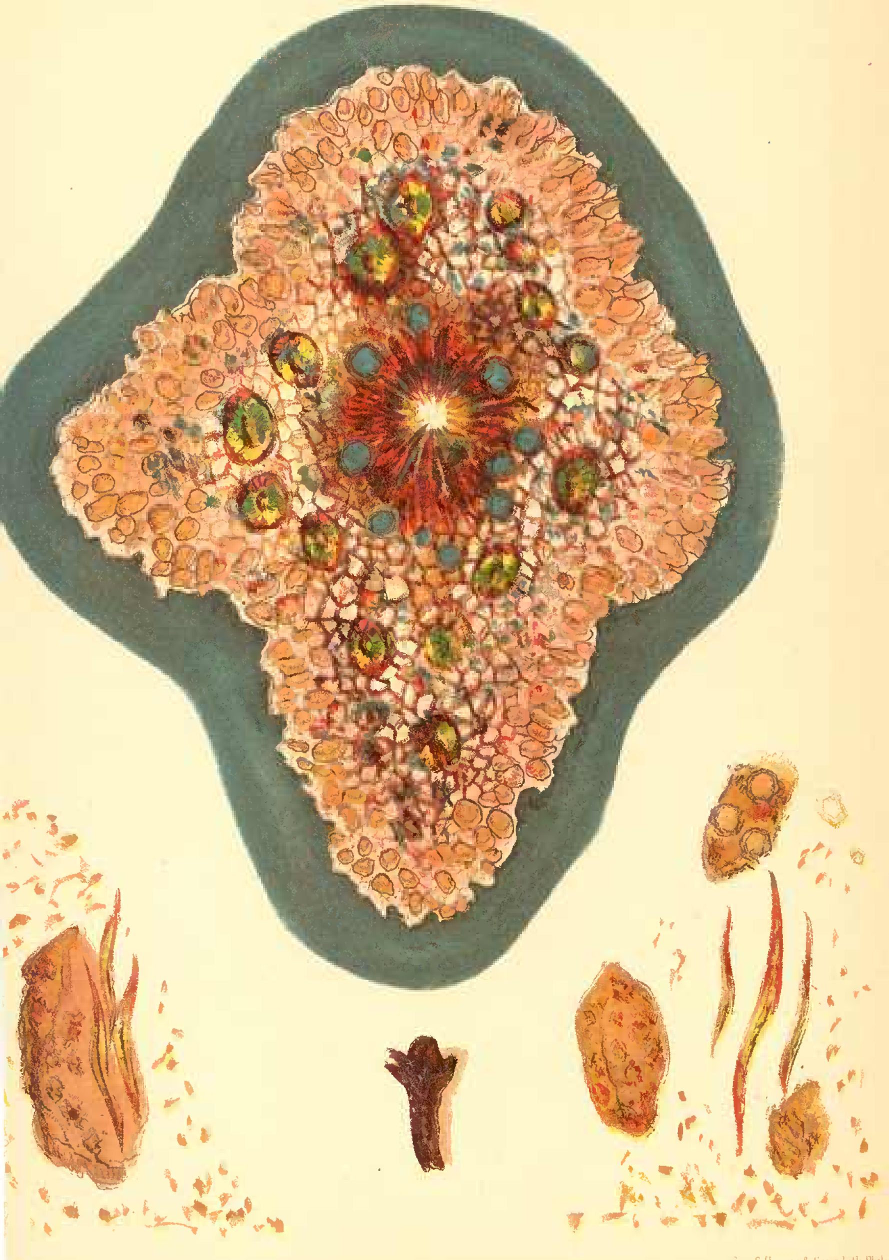
or del. Geo. S. Harris & Sons Lith Phila



BLACK MUSTARD.

aylor, del. Geo S Harris & Sons Lith Phila

Fig 1



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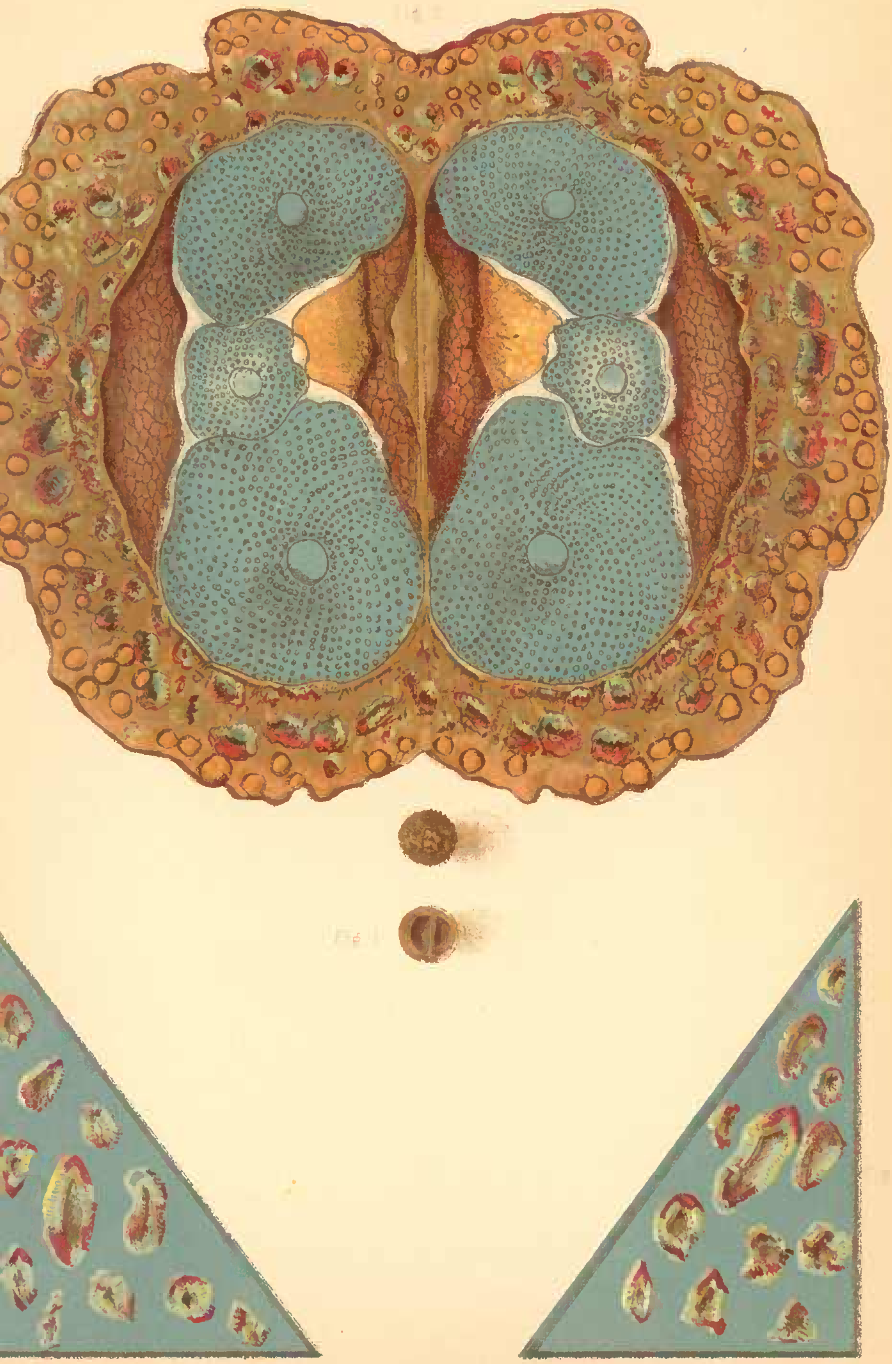
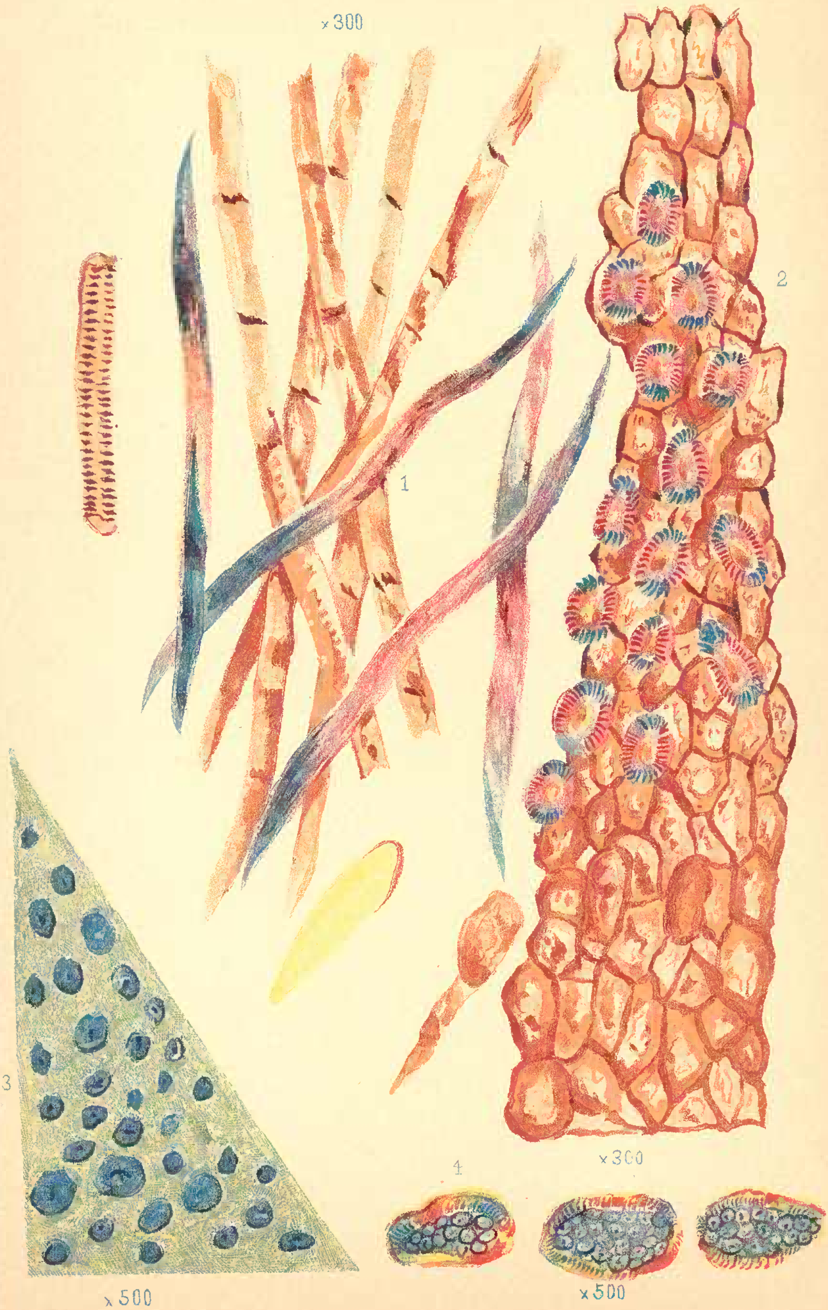
CLOVES

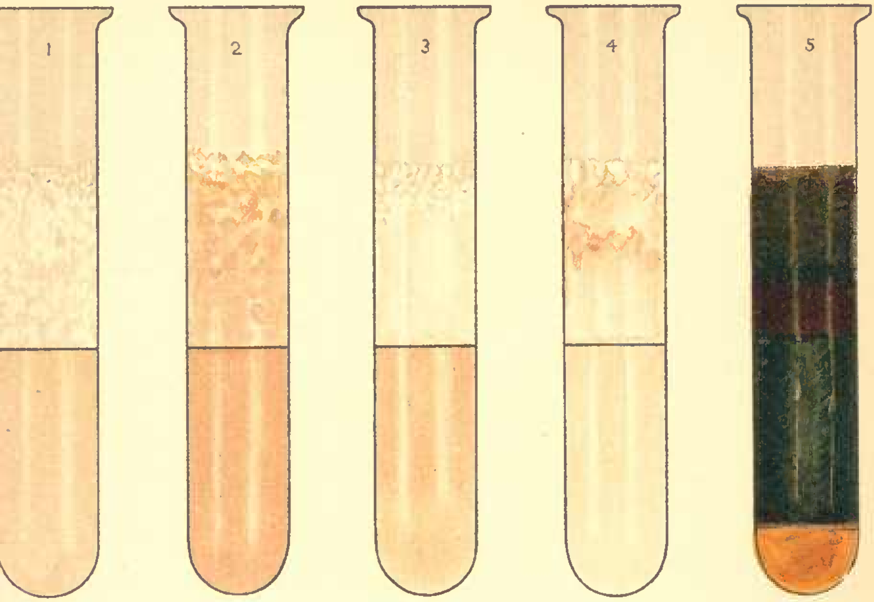


ALLSPICE

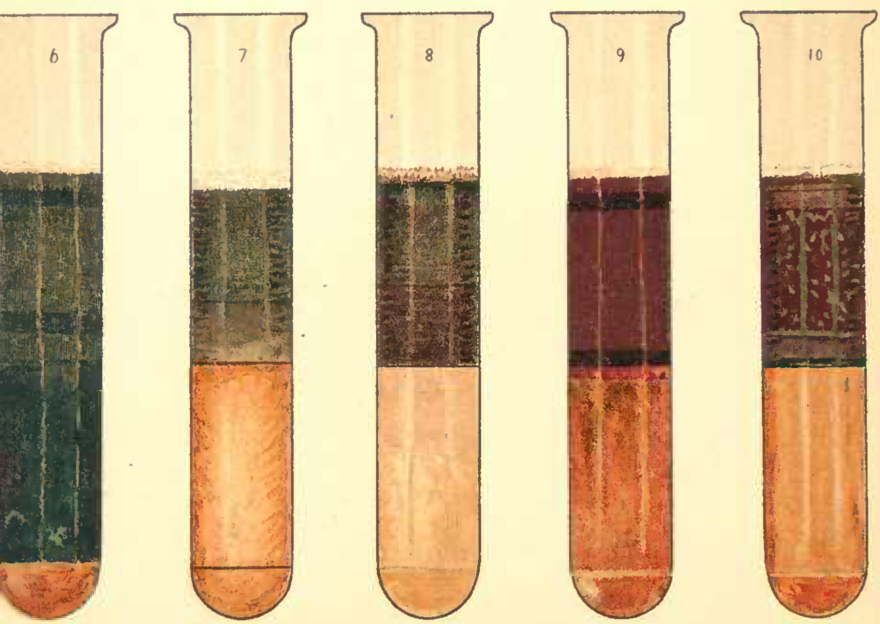
Cinnamon.



Color-Reactions of Fatty Acids, Fats and Oils, With Sulphuric Acid.



almitic Acid. Palmitin. Stearic Acid. Stearin Commercial. Oleic Acid.



Benne Oil. Olive Oil. Crude Cotton Seed Oil. Peanut Oil. "Oleo."

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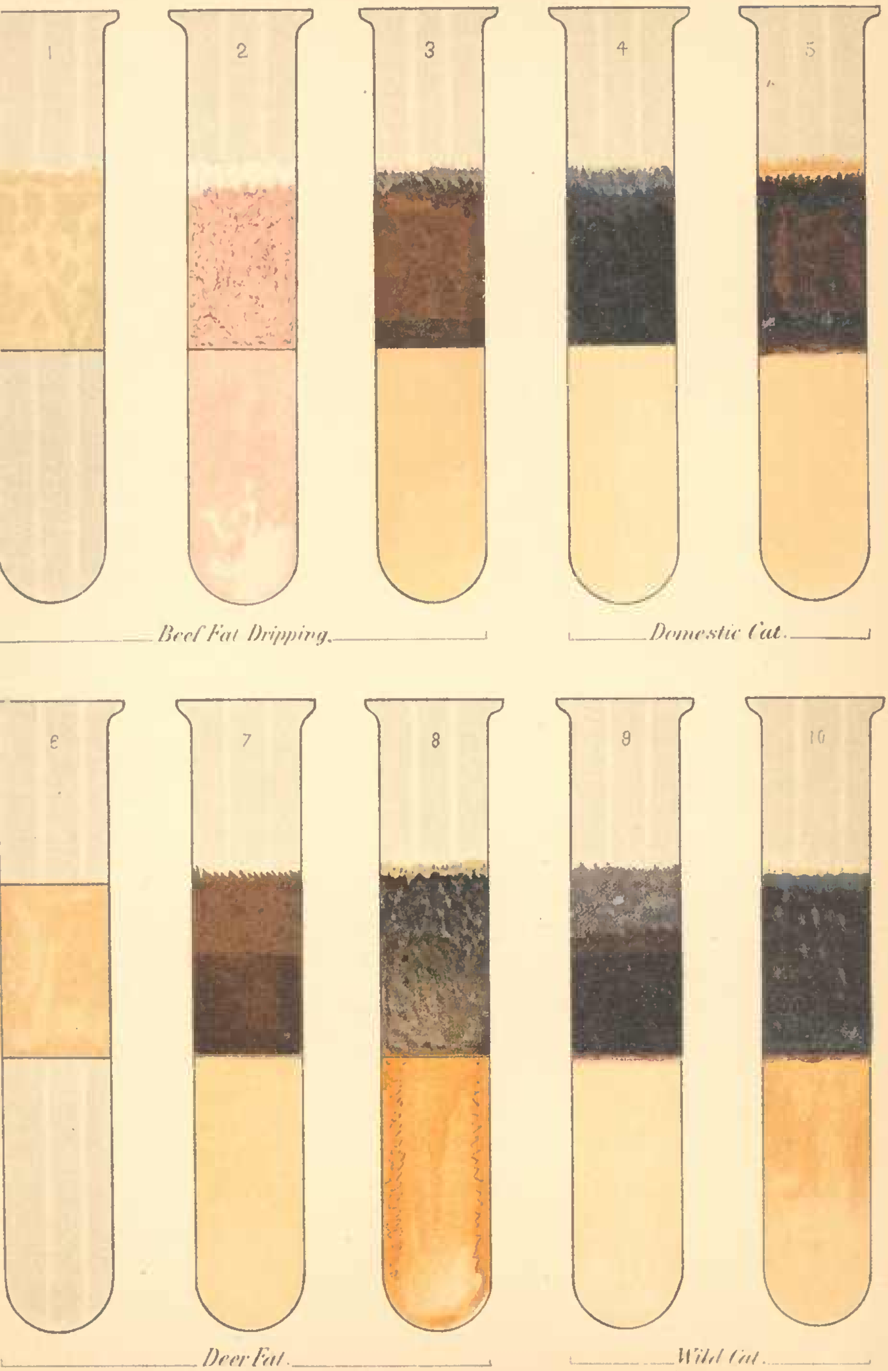
Color-Reactions of Animal Fats. With Sulphuric Acid.



T. TAYLOR, DEL.

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Color-Reactions of Butter With Sulphuric Acid.

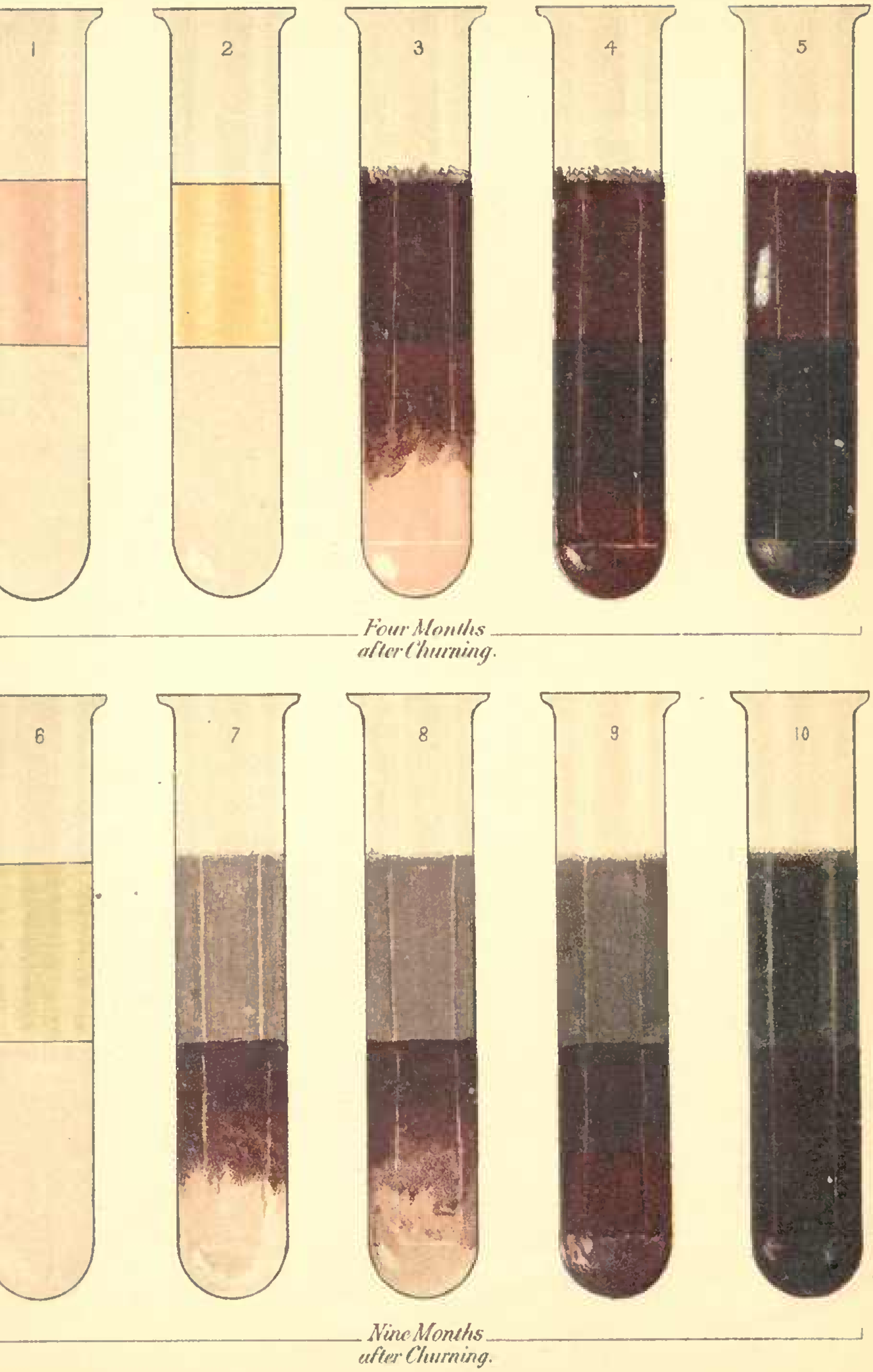

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Fig. 1.

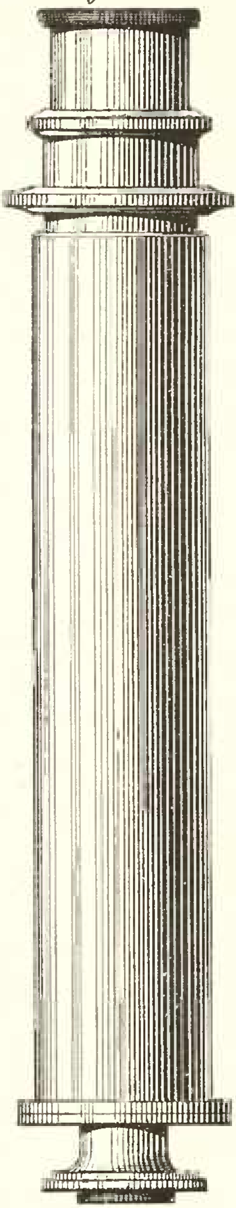
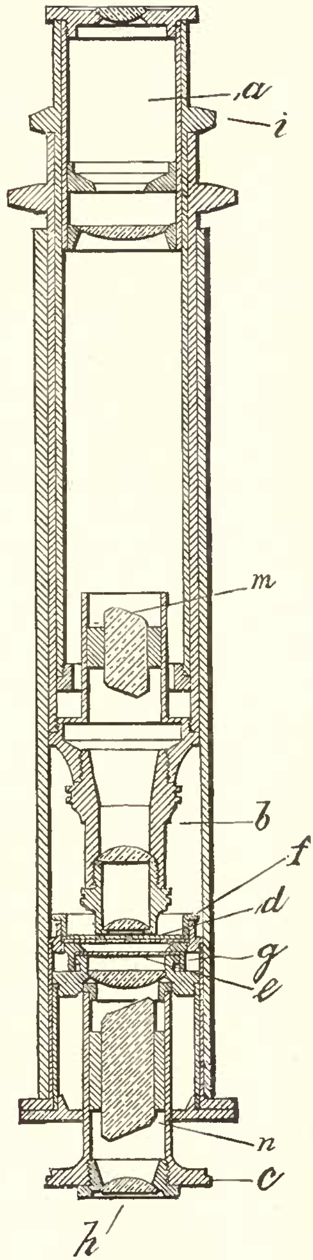


Fig. 2.



REPORT OF THE POMOLOGIST.

SIR: I have the honor to submit the following report for the year 1888:

The fruit crop of the United States for this year is the largest ever produced, there being scarcely a section of the country that has not been well supplied with the fruits usually grown there. The work of the Division of Pomology has continued to increase, and the interest manifested by the fruit-growers of the country is of a very encouraging nature. There are now on record in my office over eight thousand correspondents who have responded to the questions asked them. These and all others who have expressed a desire to receive the annual or special reports of this Division have been promptly supplied with them.

The volume of correspondence has increased to such a degree that it is only by the most vigorous exertion that the office force has been able to answer it. This is a pleasant although arduous duty, and I sincerely hope that our ability to respond may keep pace with the increasing demands.

FRUITS EXAMINED.

Within the last year the number of specimens sent for identification and study has greatly increased. Fully 10,000 specimens have been received and many of them quite rare and of special interest. In nearly all cases where the true names were desired by the party sending I have been able to give them. The experience of this office proves beyond question that there is, even in the oldest-settled parts of the country, a considerable degree of ignorance of the names of standard varieties of fruits. It is chiefly through such ignorance that local names are given to old varieties, thus multiplying synonyms and creating confusion in nomenclature and working harm to the practical grower and especially to the beginners. To remedy this evil so far as may be, is one of my constant efforts, and I am happy to say that progress is being made in that direction. To this end I wish to hereby call the attention of all who may share such a desire to the fact, that I have constantly on hand boxes made especially for transporting specimens of fruits by mail, and franks to use in returning them to this office, which will be sent to any desiring to avail themselves of the privilege. Printed directions for packing and sending will also be sent.

CABINET OF RECORDS.

There have been made and placed in the archives of this Division over three hundred drawings and water-color paintings of fruits, which, together with carefully-prepared written descriptions, are a

permanent record. This cabinet is not only of scientific interest to pomology, but also of practical value to the industry it represents. The services of a skillful artist are thus made available for preparing the necessary original copies for illustrating the reports of the Division, as may be seen herewith, as well as of assistance in comparative study and permanent record.

OFFICIAL VISITS.

In compliance with the orders of the Commissioner of Agriculture, during a part of the months of January and February I visited the State of California for the purpose of attending the meetings of the American Horticultural Society held there during that time, and to make such investigations of a pomological nature as I might see proper.

Two meetings of this society were held, one at San José, in the famous Santa Clara Valley, and the other at Riverside, in the southern part of the State, and where the orange is grown to its greatest perfection. Almost the entire State was traveled over during the visit, but at that time of year it was only possible to see the citrus fruits and olive in bearing.

To one who has never there seen the great stretches of vineyard and orchard it would be a surprise, even after reading various accounts of them.

The greater part of these plantations are on the level surfaces of vast plains and not upon slopes as I had supposed.

One very noticeable feature was the thorough cultivation. I think that on an average the weeds found on 10 acres of California orchard or vineyard could be carried under one arm, and the ground seemed to have been stirred in the most effectual manner. The soil is usually a loose sandy loam of a brownish color. Another thing that surprised the Eastern orchardists was the severe annual pruning practiced upon the peach, pear, plum, and cherry. The growth is remarkably strong on the Pacific coast, and all growers there agree that it is essential to cut back heavily every winter. This they claimed is for two reasons, viz, to prevent overbearing, and to keep the trees stocky for convenience in cultivating them and gathering the fruit. The climatic conditions are so peculiar there that I am not sure that the same method of pruning would be suitable east of the Rocky Mountains; but I think a lesson in thorough and perpetual cultivation is plainly taught. If the same attention was bestowed in this regard in the Eastern and Central States I have no doubt that much better fruit would be grown. It has been my opinion for years past that the true theory of orchard culture is to stir the entire surface of the soil frequently but not deeply (say 3 inches) during every year so long as the orchard lives. If this treatment is varied by seeding to clover for a year or two no evil may result, but in no case should small grain be sown.

During the fall an official visit was made to southwestern Missouri and northwestern Arkansas. This region seems peculiarly adapted to the growth of many of our leading fruits. The elevation above the sea-level is much greater than for hundreds of miles in any direction, making a cooler climate in summer than might be supposed for that latitude, and producing winter apples of good keeping qualities. The lay of the land is quite mountainous in places, but there is an abundance of undulating and level land upon which to plant

large orchards. The size, color, and flavor of the apples grown there are very superior. The peach seems to be at home also, and more luscious peaches I have never tasted than grew there. The peach crop rarely fails south of Springfield, Mo., west of the center of the State and east of Indian Territory. The pear also does well there, but blight is sometimes seen.

Small fruits of all kinds flourish in the rich soils. More thrifty fields of raspberry and blackberry I never saw than on the Olden Fruit Farm in Howell County, Mo. This is one of the most promising large fruit farms in the Central States. About 4,000 acres are in this tract, which is covered with oak timber, except about 1,000 acres, which have been cleared and planted principally to the peach and apple. This enterprise is already paying, although only four years have elapsed since the first clearing of the native growth and orchard planting began. Last year the gross receipts were over $9,000, and mostly from the sale of the first crop of peaches on the oldest trees. No disease and very few borers have to be contended with in peach culture there.

The grape grows and bears well, but so far it has not been considered as profitable as the orchard fruits.

To those desiring to move to a country of mild winters, and summers not too warm, and engage in fruit growing, I know of no better place in the Central States.

INVESTIGATIONS IN FOREIGN COUNTRIES.

Prof. J. B. Steere, of Ann Arbor, Mich., having determined to visit the Philippine Islands for scientific investigations, I arranged with him to secure for this Department such seeds and plants as he might think valuable for trial in the more tropical parts of this country. He forwarded seeds of several species of *Anona* and of the best varieties of the mango found there; but I am sorry to say that the latter were (as I had feared they would be) entirely dead upon arrival here. Plants of six varieties of the banana came through in good order. The above were at once sent to southern Florida for trial.

In connection with this it may be of interest to give a part of Professor Steere's letter to me, written while there:

> The natives seem to have made no attempts at improving the fruits that have fallen into their hands, and the Spanish, their masters, have made as little, so that any excellence in the fruits of the country, or, in fact, any other products, will depend on the natural character of the country or on that of the original introductions, if they are introduced kinds. Unfortunately the citrus fruits, of which you spoke more especially, are one of the least cultivated, and rather poor in quality. The oranges appear to have been introduced from China, and have gained nothing in transportation; a loose-skinned small one is cultivated about Ilo Ilo of good quality. Lemons are of poor quality but of large size. Limes are good, but the pomelo is not equal to that of China. On the other hand, the bananas are of many varieties and of most excellent quality. These islands would seem to be one of the original habitats of Musa. There are at least three wild species, I believe. One of these is the "abacao," which is now cultivated on the islands for the product, Manila hemp, and seems to have been in use from time immemorial by the people as a material for clothing, fishing nets, etc. It rarely fruits, and loves a cool, moist climate best; the finest specimens I saw were at a height of 2,500 feet, in the island of Negros, and with the thermometer marking 67° F. at night. The fruit is said to be full of seeds, like that of the other wild species. There is a second wild kind abundant in these central islands called "pacol" by the natives; its fiber is also used as a textile, and is finer but weaker than abacao; its fruits are greenish-yellow, angled or ribbed like the banana sold in the home (American) markets, and what pulp there is is sweet and

high flavored, but full of black seeds a little larger than apple seeds. The plant grows to a height of 12 to 15 feet, and is found in large numbers, sometimes occupying several acres to the exclusion of everything else. The fruit is eaten by birds and monkeys, and the natives also use it. At the south, in Mindanao, there is a third species with smaller and smooth yellow fruits, but also full of seeds. The cultivated varieties are very many, perhaps fifteen or twenty, and many of them are much finer than anything I ever saw in South America. I should think several of them would be very suitable for transportation and would be a fine addition to the fruits sold in our markets, but whether fitted for any part of the United States I do not know. I shall return in August or September, and might bring along plants of all the better varieties obtainable, if you thought it desirable.

The mangoes of the islands are of several (about three) varieties, and of excellent quality. Here in the central Philippines the trees are large and of great beauty, spreading, and the branches reaching the ground on every side, forming great masses of dark green, which are landmarks, as they can be distinguished from all the other vegetation. The trees have an irregular way of shedding their leaves which is curious—shedding them on one side or one branch at a time, and the fruiting of the tree is determined by this.

Cocoa-nuts are here of great excellence and a great number of varieties, but of course would be of no use to you.

I found at Tamboanga Mindanao, a fruit—one of the custard-apples—of very excellent quality, resembling the cherimoya of Peru in shape, flavor, and seeds, but reddish in color; it is probably, I should think, a South American introduction; perhaps changed by the conditions found here. I have preserved seeds of it.

The guava of South America has been imported here and has run wild in great quantities in waste places, but has not been improved by the change.

The durion exists at Tamboanga, but did not fruit this year, so that I had no opportunity to test its quality.

The Spanish priests have introduced the grape, and one sees vines frequently about their houses, but it leads a sorry existence, and I have not yet seen it fruiting.

The nanca or jack-fruit, I believe, grows abundantly and of enormous size, but as elsewhere is coarse and unfitted for our taste.

Water-melons and musk-melons are practically unknown.

I shall be coming back at a time that will allow of bringing living plants with me, and if there is anything needed in your Division of the Department, or any other, which I can obtain, I shall be glad to undertake to bring it.

A number of fruit seeds have also been received and distributed from Japan, the East Indies, and South America.

Plants of fifty varieties of the best English gooseberries were imported and distributed in Oregon and Washington Territory. They are reported as growing thriftily, and it is expected that they will succeed there quite as well as in England.

OUR WILD FRUITS.

The wild fruits of the United States are certainly of such great value that every possible means should be employed to thoroughly investigate them in their natural localities, and introduce to cultivation such as are likely to prove of value to the practical pomologist, or the scientific experimenter. Many of the most valuable fruits now cultivated in America are entirely of native origin. There are very few varieties of the grape planted and successfully grown in the vineyards east of California and New Mexico that are not direct descendants of the wild species of our forests and thickets. And yet the natural field as regards this fruit alone has been as yet but poorly explored.

The Concord is but one remove from the wild *Vitis labrusca* as found in the woods of Massachusetts. The people of the United States will never fully appreciate the value of the labors of Mr. Bull in originating this variety; for they not only resulted in placing this delicious grape on the tables of the rich and poor alike, at a small price, but the Catawba, the Delaware, and all other grapes pre-

viously grown and sold for more than the poor could pay, were thereby lowered in price, and a stimulus created in grape culture which will never cease to be a blessing to our people. Norton's Virginia is a wild seedling of *V. æstivalis* that stands to-day as one of the nearest proof against the dreadful fungus diseases, and unsurpassed as a wine grape by either foreign or native varieties. The Clinton, which is a pure seedling of the wild *V. riparia* (a species that has the widest natural range of territory of any of the genus), has proven so well able to resist the attacks of the dreaded phylloxera upon the root, that French vineyardists have bought millions of the plants and cuttings upon which to graft their more delicate varieties.

As yet the wild grapes of America have but barely begun to be utilized. In my last annual report I said that the investigation of this subject by this Division had been taken up, and I have now to report that the results of the work of the year 1888 have been of the most interesting character. A monograph of the genus *Vitis* is being prepared for publication by the Division with the assistance of Mr. T. V. Munson, of Texas, as a special agent, and a considerable part of the work is already done. As the field-work, the preparation of the original colored illustrations, and the literary part also progressed, it became evident that we would need all of another year to complete it. The number of species known to be native in America has increased from twenty-two to twenty-six within the last year as a result of our field-work, and present indications are that more may yet be found. Some varieties lately discovered have such good qualities that they will be of special value to our vineyardists even without the improvement that cultivation will immediately bring about; as the basis of varieties that may and will be produced by hybridization they are certain to be of the highest value.

The patience of many correspondents is bespoken with this work; for the value of accuracy and completeness, as near as may be reached, is too great to be jeopardized by hurry and premature publication.

But the grape is by no means the only wild fruit that deserves attention, or that is receiving it. The wild plums are fast becoming a popular orchard fruit, not that they are as good in quality of fruit as the European varieties, but their comparative ability to resist insect attacks gives them a great advantage. If it were not for our native species, our markets and our tables would rarely be supplied with plums, except in a few favored localities. As it is, there need not be a farmer or owner of a village lot who may not have an abundance of this fruit by taking quite ordinary pains to produce it. The varieties differ sufficiently in time of ripening to cover a period of fully two months.

There are but few of the small fruits commonly grown in the United States that are not the product of her native flora, improved by the skill of her citizens, or wildlings selected directly from the hand of nature.

It is my purpose to expend all the time and money that can be justly devoted to such work in field investigations with a view to determining the territory occupied by each species, their botanical relationships and variations, and to discover and preserve for culture and scientific experiment such as may be likely to prove worthy. There is no doubt that every year many chance seedlings of wild

origin disappear before the ax and fire of the settler. Such cases have been reported to this office, and others have been frequently brought to public notice.

PARIS EXPOSITION.

This Department having, by act of Congress, been directed to prepare an exhibit for the Paris Exposition during 1889, it became my duty to attend to that part of it relative to the fruit industry. This work is but partially begun, but it is expected to secure an exhibit of dried, canned, and preserved fruits that shall be a credit to the country.

THE APPLE.

The year 1888 will be remembered as a remarkable one for an abundant apple crop in all the States where that fruit is grown. In some places good winter apples would only bring the grower about 10 cents per bushel, and many thousands of bushels were allowed to rot in the orchard because of no market demand. In Ohio and some of the neighboring States where last year there was almost no crop, this year there has been an abundant one and of excellent quality. In Wisconsin, Minnesota, Dakota, northern New England, and parts of Iowa and Nebraska where the apple is grown with difficulty, there has not been so much failure reported this year as usual. During the past year there have been received at this office about fifty varieties of Russian apples, principally from Iowa. Their season of ripening began about August 1, and with very few exceptions ended with September. Their perishable character was very noticeable upon the table here beside the ordinary summer apples of the country, and the opportunity for testing them together was very good. Their flavor, I am sorry to say, with one or two exceptions, was very poor, and insipid or sour and astringent. In appearance they were generally quite handsome, and some were exceedingly so, but not in this regard superior to our old varieties. In size they averaged rather small. I give in this report accurate descriptions of four varieties which are rather above the average in quality, and only wish that I could say better things for them. The blight has also been very severe on the Russian apple trees this year, which seems to be the most serious defect, next to their scarcity of late-keeping varieties. It may be that some kinds now being tested may prove to be winter apples in the United States. It is, however, not to be inferred that those which are late keepers in Russia will be the same in season here, for experience with many varieties from there has proved this to be true.

The varieties described in this report are such as fairly represent this class of apples.

VARIETIES.

Jefferies.

If I should be asked to select the choicest early autumn apple known to me, I would say the Jefferies. It is a chance seedling that originated in Chester County, Pa., and was first brought to public notice by the Pennsylvania Horticultural Society about the year 1853. It has been propagated and planted to a slight extent all over the country, and in all cases heard of it has been highly praised.

The tree is of upright growth, forming a beautiful head. The twigs are slender and of a reddish color. The leaves are rather narrow and bright green.

It begins to bear early, and is one of the most constant and abundant bearers of which I have any knowledge. No family orchard should be without it, and for market I have good authority for highly recommending it.

The illustration on Plate No. 1 was made from a specimen grown by Rev. S. M. Irwin, of Geneva, Kans.

Size, medium; shape, flat, slightly conical, regular; surface, smooth, yellow, profusely covered with carmine stripes and crimson splashes; dots, large, light, scattering; basin, medium, regular; eye, closed; cavity, rather deep, sloping, slightly russeted; stem, short; core, medium, meeting the eye; seeds, numerous, plump; flavor, sub-acid, rich, aromatic; quality, best; season, August and September in the Middle States.

Borovinka (No. 245).

This is one of the varieties imported from Russia in 1860 by the U. S. Department of Agriculture and distributed under the number "245." The specimen from which the accompanying Plate No. 9 (Fig. 1), was made, was grown this year by C. G. Patten, Charles City, Iowa.

Size, medium, diameters 2 by $2\frac{15}{16}$, axial, $1\frac{5}{8}$; shape, flattened oval, regular, unequal; base, wavy; surface, uneven, greenish-white, mottled, splashed and striped with red; dots, minute, white; basin, shallow, dished, little crimped; calyx, closed, segments broad and long, eye deep; cavity, abrupt, deep, and regular; stem, very long, slender; core, large, broad, flat, closed; seeds, round, flat, dark-brown; flesh, yellow, tender, grainy, dry; flavor, mild, sub-acid, pleasant, not much character; quality, poor; season, September in Iowa.

Prolific Sweeting (No. 351).

Of all the Russian apples that I have tasted so far this is the best in quality. It was grown by Dr. T. H. Hoskins, Newport, Vt. (See Plate No. 9, Fig. 2.)

Size, medium, $2\frac{3}{8}$ by $3\frac{1}{4}$, axial $1\frac{1}{2}$; shape, irregular, flattened conical, base and apex very irregular; surface, smooth, yellowish-white, tinged with green; dots, many, minute, indistinct, white, also a few are distinct and of a russet color; basin, broad, shallow, irregular, and very much folded; calyx, small, closed; eye, closed; cavity, irregular, deep, a little light russet; stem, medium thick, curved, light-green; core, medium, closed, clasping, "watery;" seeds, numerous, broad, flat, light-brown; flesh, white, fine grained, firm, juicy, clear water-spots; flavor, sweet, very pleasant; quality, good; season, September in Vermont.

Zolotoreff (No. 275).

Grown by C. G. Patten, Charles City, Iowa. (See Plate No. 10, Fig. 1.)

Size, $2\frac{1}{4}$ by $2\frac{3}{4}$, axial $1\frac{3}{4}$; shape, irregular, flattened; surface, smooth, color white, slightly blushed and faintly striped on one side; dots, minute, white; basin, shallow, irregular; calyx, large, open, segments short and broad, far apart; eye, broad and open; cavity, shal-

low, irregular, russet; stem, short, thick, fleshy, lipped, inclined; core, large, clasping; seeds, large, brown; flesh, white, coarse and grainy, dry; flavor, acid, unpleasant; quality, very poor; season, September in Iowa.

Red Transparent (No. 333).

Grown by C. G. Patten, Charles City, Iowa. (See Plate No. 10, Fig. 2.)

Size, medium, $2\frac{1}{8}$ by $2\frac{5}{8}$, axial, $1\frac{7}{8}$; shape, flat, irregular, angular, unequal; surface, smooth, green, lightly mottled and striped with red, thin, white bloom; basin, shallow, narrow, irregular; calyx, closed; eye, round, short; cavity, nearly none, dark green about stem; stem, very short, woolly; core, large, open; seeds, few, very broad, almost round, flat; flesh, greenish-white, tough, juicy; flavor, sour, acrid, astringent, disagreeable; quality, poor; season, September in Iowa.

THE PEAR.

There are several new varieties of this fruit coming to notice each year, and I have selected two of the best for illustration and special description.

Wilder.

Among the midsummer pears there is none that pleases me better than this one, except that its size is rather small. But like the Seckel, what it lacks in size it makes up in quality, although it is larger than that variety. It is a chance seedling found in Chautauqua County, N. Y. The original tree was partially grafted with scions of Buffum in 1870, when it was young, and would never have borne any fruit except of this old variety had not three of the natural branches been left. These bear profusely, and the fruit when fully colored is quite attractive. It does not rot at the core.

Size, small to medium; shape, pyraform, bell-shaped, irregular, a little angular; surface, smooth, pale-yellow ground with deep shading of brownish-carmine; dots, very numerous and small; basin, shallow, regular; eye, nearly closed, sepals long and reflexed; apex, rather abrupt with a slight cavity; stem, short; core, closed, very small; seeds, very small, narrow, pointed, dark; flesh, very pale, whitish-yellow, fine grained, tender; flavor, subacid, sprightly, much like Bartlett; quality, very good; season, August, in western New York.

The colored drawing on Plate No. 3 was made August 10, 1888, from a specimen sent by Charles A. Green, of Rochester, N. Y.

Idaho.

This pear has been attracting so much attention and is of such real value that I take pleasure in giving it a place in this report. It is a variety raised from seed saved from an unknown variety and planted about the year 1867 by Mrs. Mulkey, of Lewiston, Idaho, and first brought to public notice in the fall of 1886 by Mr. John H. Evans, of that place. It has been stated in some of the papers that it is of Chinese parentage, "similar to Keiffer," but my opinion is that this

is a mistake, for the fruit bears no resemblance to that class either in flavor or texture. It is much like Angouleme in both these characters.

Specimens received at this office October 4, 1888, from Mr. Evans were in fine condition, and the illustration on Plate No. 2 of this report is as near exact in color, size, and shape as could be made, and is not exaggerated in any respect. The original tree began to bear fruit four years from the seed. I would recommend it for extensive trial, as the tree has already proven itself to be hardy in several northern States.

Size of fruit from 4 to 4½ inches diameter; shape, a little flattened, tapering slightly both ways from the center, quite irregular, depressed at the stem; surface, rough and uneven, yellow or straw color, with a faint blush or brownish-red on the sunny side, and a few bronzed blotches; dots, minute, dark, and very numerous; basin, deep, flaring, very irregular or ribbed, and thickly covered with fine brown dots; cavity, medium, abrupt, irregular; stem, stout and rather long; core, very small; seeds, few; flesh, almost white, fine grained, buttery, melting, lacks the grit so often found in pears; flavor, sweet, to mild subacid, rich and aromatic, juicy; quality, very good; season, September in Idaho.

THE PLUM.

Plum culture seems to be getting more popular as the improved varieties of the native American species become known, and also the benefit of spraying with arsenical mixtures to prevent the depredations of the curculio.

Wayland.

Among the host of native American plums that have been brought to notice this is the best one I have yet tasted.

Concerning the history of this plum Mr. T. V. Munson has given the following:

Downer & Brother, of Fairview, Ky., wrote me, November 3, 1888, in answer to my question for its origin, etc., the following:

"As to origin of Wayland Plum, it was sent us (J. S. Downer & Sons), during father's life, by Prof. H. B. Wayland, of Cadiz, Ky. We understood it to be a seedling on his premises, as he said it was in a plum thicket. We named this one Wayland. We introduced it but have lost sight of Professor Wayland; do not know that he yet lives."

It is of the same type or species as the Golden Beauty (discovered during the civil war, in western Texas, on the Colorado River), disseminated by G. Onderdonk, and the Kanawha plum, disseminated years ago by P. J. Berckmans. The origin of the latter I do not know. I suspect the Wayland is a seedling of the Kanawha.

Last August, when on a tour of investigation of native grapes and other wild fruits, I found a thicket of plum trees of the same character as the Wayland, being full of late fruit similar to that variety. I consider these all of the same species—*Prunus umbellata*, with whose botanical description they pretty well agree. They are certainly not of the Chicasa species, as commonly supposed.

The curculio may deposit eggs in the young fruit, but no signs of them can be discovered in the mature fruit. Neither are they affected with rot in this region, as are the varieties of *Prunus domestica*, or European Plum, and the Wild Goose, sometimes.

They ripen here in the last of August and first of September, about with the Heath Cling peach.

The stone is small, smooth, and ellipsoidal. The fruit makes fine jelly, jam, and preserves, and also cans well. No black knot or other disease yet noticed on any of this class.

In size it is fully as large as Wild Goose, nearly round in shape, and of a brilliant reddish purple. The season is quite late, in fact the latest of any good native American plum that I have seen. The quality is very good, and when cooked it is not sour as is the case with nearly all native varieties. In productiveness it is not excelled, a statement that I have the best of evidence to confirm. The illustration on Plate No. 5 was made from specimens sent me and grown by T. V. Munson, of Denison, Tex.

Clyman.

The subject of this sketch is not only a novelty but a noteworthy departure from the usual type of the varieties of the garden plum of Europe—*Prunus domestica*. It grew from a seed planted in 1866 by Mrs. Clyman in the Napa Valley, in California, and is supposed to have been taken from the old "Peach" plum. It first attracted attention by maturing its fruit long before any other plum of this family, being about with Wild Goose. The original tree having outgrown its surroundings three sprouts were dug from the roots, which are now ten years old, and have borne fruit continuously for the last six or seven years. The tree is a very vigorous grower and the leaves are extremely large, as samples of young shoots received from California this year testify. On the bearing branches they are much smaller, as the accompanying plate, No. 4, shows.

The first ripe fruit was picked this year at Napa City, Cal., on June 15, which is fully four to six weeks in advance of ordinary plums. Of course it may be expected to be subject to the attacks of the curculio, and should only be grown where a reasonable degree of immunity exists, or by those who expect to use defensive means against this dread enemy.

The fruit is round in shape, slightly flattened at the end opposite the stem, with a distinct suture on one side. The skin is a dark purple, with a heavy bloom over all, which gives it a rich bluish color. The flesh is yellow, firm, and of delicious flavor. When ripe it is a perfect freestone. The principal merit over the old varieties lies in its earliness, which makes it profitable for market purposes long before all other plums of this class.

I am indebted to Mr. Leonard Coates, of Napa City, Cal., for the specimens and the information here given.

THE PEACH.

The peach crop this year was unusually good over a great part of the United States, and generally of superior quality.

The peninsula which comprises Delaware and a part of Maryland is, perhaps, the mecca of the peach-grower, but that dread disease, "the yellows," is making sad inroads upon the industry there. But as the subject is now being thoroughly investigated by the best scientific experts to determine the cause, and, if possible, a remedy, it is hoped to be able to check, if not to overcome it.

The peaches of California are attracting much attention in the markets of Chicago and other of the more northern and central cities, where they are received in the fresh state, and the dried and preserved product from that State is also becoming very popular.

Parts of Arizona and New Mexico are well suited to peach culture, and will in time come more prominently before public notice in this

regard. The extreme southern parts of the Union are forced to cultivate a quite different class of varieties from those grown in what is known as the peach-growing sections. This matter is set forth very plainly in my annual report of last year (1887).

The facts seem to be that there is not enough cool weather in the greater part of Florida to afford sufficient cessation of growth in the ordinary kinds of peaches, and they either bloom at a time when they are killed by frost or do not bloom at all. In short, this strain of the peach family is out of climate there.

But when the Peen-to was introduced from China, an impetus was given to peach-growing in Florida. This variety soon bore fruit, and although small and of a peculiarly bitterish flavor, it was far better than none. The peculiar flattened shape made it a novelty, but its extreme earliness was the peculiar point of value, as it enabled the grower to place ripe peaches on the markets of the North during the early part of May.

Seedlings of the Peen-to were soon produced, which in some cases retained the flattened shape, and some were like ordinary peaches.

Bidwell's Early.

Mr. I. A. Bidwell (now deceased) began the planting of seeds of Peen-to in the winter of 1882. Two of the first nine seedlings that he grew were exactly alike in all respects, and produced fruit so different from and so much better than the parent that it was named in his honor.

In size it is from 1 to 2 inches in diameter, of an oblong shape, and pointed a little to one side of the center. The color is a creamy white with delicate blush on the sunny side. The stone is rather small and tapering, often split at the base and to which the flesh adheres slightly. Samples were sent me for two years past by Mr. James Mott, of Orlando, Fla., and the picture on Plate No. 6 was made from one of them.

There are many other new seedlings of this character lately originated in Florida, and some of them may in time prove to be more valuable than this one.

The Dwarf Juneberry (*Amelanchier oblongifolia*).

Nearly every person familiar with the trees and plants of his own State has gathered and eaten the Juneberry, or as some call it, "Serviceberry." The common species is a small tree, and there are few country boys in the Central States who have not climbed the trees in the early summer for their toothsome berries. There is, however, another branch of this botanical genus, which some claim is a distinct species, and others that it only a sub-species, that is of dwarfish growth, being about 4 feet in height, and in manner of growth much like the wild hazel. It is found wild in some parts of the Alleghany Mountains and in the Lake Superior regions and westward. It seems to me that there are specific characters sufficient to make at least two species of *Amelanchier*, if not several, among these dwarf forms.

At least one of them (*A. oblongifolia*) thrives well under cultivation and is becoming quite popular as a small fruit, especially in the prairie States west of the Mississippi River, although not native in that region so far as I know. There are several varieties which differ

slightly in height of bush and color and shape of foliage. The fruit also varies a little in color but is generally a dark purple when fully ripe. One variety in Missouri is said to be white. The fruit is a berry-like pome, nearly the shape and size of the common huckleberry. The flavor is sweet, or mild subacid, and by some thought to be too sweet for cooking purposes. It is very nice when made into sauce or pies mixed with green gooseberries, as the sharp acid of one and the sugar of the other seem to make a very good combination. I do not think it will ever rank equal with some of our leading small fruits; but it is certainly well worth a place in a family berry patch.

The plants propagate from suckers that spring up near the base of the bushes, but do not become a nuisance. They should be set about 2 or 3 feet apart in rows 8 feet apart and where they will never need moving, for once planted they will continue for one's life-time. There are no thorns, and insects do not seem to prey upon either plant or foliage or fruit. They transplant easily and are remarkably hardy from the Great Lakes to the Gulf. I have known plantations in Kansas, Nebraska, and Illinois for the last fifteen years, and they have never been killed by the heat of summer or the cold of winter, and one large patch on my own farm has never failed to bear abundantly in all that time.

Success.

This is a variety of the Juneberry that I prize more than any that I have ever tasted, and a colored illustration of it may be seen on Plate No. 7 in this report. It is now being sold by some of the leading nurseries af reasonable prices.

The Pepino (*Solanum Guatamalense*).

This plant is also called the "Melon Shrub," and has been quite thoroughly tested in the United States and found to succeed only in a very few places in Florida and California. It came originally from Peru and Guatemala. It was first brought to California by a Mr. Grelech, of Los Angeles. It has been so well described by him that I give an extract from what he says regarding it:

The Melon Shrub, as it grows in the Central American highlands, is, as the name defines it, a shrub. It reaches at its best 2 or 3 feet each way, but is generally smaller, and recalls in many respects the Chili pepper vine, the tomato, or the nightshade. The flowers resemble those of the Chili pepper, are very numerous and of a beautiful violet color, and are most charming when used in floral decorations. The plants should be set in rows 4 feet apart and 2 feet in the rows. A month and a half after being set out the fruit will begin to set, and in three months after planting the fruit will ripen and continue to ripen until checked by frost. The fruit is of the size of a hen or goose egg, or even larger, and very much of the same shape. The color is lemon or pale orange with streaks or waves of bright violet, the whole making a fruit unrivaled in beauty. The interior of the fruit is a solid pulp similar to that of a pear, also of a pale-yellow color, and of a taste resembling that of a fine musk-melon, but which has besides a most charming acid, so wholesome and so delicious that when the fruit is partaken of on a very warm day it allays the thirst for several hours. The plant is an enormous yielder. I have seen plants of small size, say 2 by 2 feet, bear 30 large fruits, which from their size and weight pressed the branches to the ground, and thus formed a most beautiful border all around the plant.

The Melon Shrub can stand light frost, but heavy frost will cut it to the ground. The dead branches should then be cut off, the plants covered with an inch or so of straw, and it will, if so protected, start up in the spring as vigorously as before.

Having decided upon the merits of this plant, and being satisfied that it will be-

come a most welcome addition to the fruit not only of California but of all the Middle and Southern States of the Union, we decided to bring the same with us to California and try it here. After a good deal of trouble, and I must say no little expense and anxiety, we have now eminently succeeded. Our experience has been, we think, most valuable to us. The Melon Shrub grows in California even better than in Central America, and the fruit is decidedly superior.

The following paper on "Our Cultivated Fruits, Native and Introduced" was prepared for publication by your direction, and although it covers a part of the same subject treated more fully in a special report on "Tropical and Semi-tropical Fruits," issued by this Division last year, yet I trust it will serve a good purpose to have it appear in this report.

Thanking you for the very deep interest you have constantly shown in the work of this Division, I am, sir,

Most respectfully,

H. E. VAN DEMAN,
Pomologist.

Hon. NORMAN J. COLMAN,
Commissioner of Agriculture.

OUR CULTIVATED FRUITS—NATIVE AND INTRODUCED.

[A paper prepared by W. H. Ragan, of Greencastle, Ind., under the supervision of the Pomologist.]

Horticulture is truly "an art which does mend nature." Were it possible for us to return even to medieval times and compare the conditions of pomology in those days with the present, we would certainly recognize the wonderful influence which man has wrought upon the fruits of the garden and the orchard.

The edible fruits of those early days were few in numbers and but slightly removed from the original types of the species to which they may have belonged. The liberal Hand which has so bounteously blessed us with the luscious fruits of our gardens, wisely designed that we should earn, to some extent, through acquired skill and knowledge gained by experience and observation, an influence over the fruits, which should enable us to so modify and change their natures as to better please and satisfy us. What we may assume to be an improvement upon nature may, however, only be a delusion, for in reality the perfect type of the species is that which is nearest to the hand of the Maker. Hence, the tree with its knarled body and thorny branches, and its load of austere, seedy crabs, was placed before us as a perfect type of the apple. In this were combined perfect health and vigor of tree with all the qualities necessary to the fighting of its own battles, and with procreative powers sufficient to insure the perpetuation of its species and the reproduction of offspring, without limit, which should, in turn, possess the same qualities of perfection.

This was the original apple, each generation of which, in a state of nature, was an exact counterpart of the generation preceding it—the same wild, thorny tree and the same seedy, acid fruit. But man did not highly value some of these qualities of perfection in the original species. He cared not for the numerous seeds, nor for the knots and thorns with which the tree was protected, as by an armor. It was the pulpy, edible envelope that surrounded the seeds that he prized, not caring whether this, to him, desirable portion covered, protected from harm, and nurtured the germs of future generations or not, so his wants were supplied.

It has already been said that man was given certain influence over these wild products of nature, which he could only discover by the slow process of practical experience and observation. As man was given "dominion over the beasts of the fields," so he also was endowed with powers to subdue the wild habits of the fruits of the forests and groves about him. The rational and intelligent way of accomplishing these results was, first, by removing the tree or plant from its wild surroundings, where it must struggle for existence, and placing it under his protecting care, where it might be supplied with all needed elements of plant food; and, second, by judicious and careful selection of seeds and germs, for the propagation of other and improved generations of offspring.

By these processes the rough, wild, self-reliant and self-perpetuating nature is gradually and surely overcome, and what was once an untamed species becomes

domesticated—trained to sport into varieties and forms widely differing from the original. Thus, generations of unconscious experimenters have gone before us in this interesting and profitable work, the results being manifested so slowly as to overtax the patience of any but a hopeful horticulturist, each age of experimenters leaving, perhaps, but little beyond a visible evidence of progress.

This process of domesticating and subduing our natural fruits progressed, until man, from being a mere experimenter, becomes a scientist; from the results being simply accidental, they become almost definite, under the controlling influence of the art of horticulture.

HORTICULTURE AN ART.

We have said that horticulture was an art. Its triumphs consist in molding, to a certain extent, nature's plants and their products to suit our fancies and our tastes. Botany is a science which finds in the plants of nature the perfect types of a species. A fruit, botanically speaking, is the natural ovule; the portion of the plant capable under favorable circumstances and conditions of reproducing its species. A fruit, pomologically considered, is the pulpy edible envelope or receptacle on which, or in which, the ovules are supported and matured. The fruit botanical is not the fruit sought to be improved and developed through the arts of horticulture, but the fruit pomological. Seeds and germs are of secondary importance to the horticulturist, since they are valueless only as they serve his purposes in the reproduction of new varieties, his art and acquired skill enabling him, when once a desirable variety is produced, to perpetuate it without again resorting to seeds. Thus we find our cultivated fruits, especially those most highly developed and therefore most highly prized, to possess fewer and smaller seeds in proportion to bulk and other desirable qualities than the original species in a state of nature. Indeed, these improvements have been carried so far in case of the cultivated banana and some varieties of grapes, pears, oranges, and other fruits as to have almost entirely eliminated the seeds, leaving only the desirable edible portion.

It is also possible to cultivate, with a given object in view, until varieties are so thoroughly established, as in case of the Heath peach, that they will reproduce themselves from seed, or varieties so closely resembling the parent as to be readily recognized by family features and characteristics. The discovery and recognition of these results have directed and encouraged the intelligent pomologist further and further in the line of investigation and experiment until, as above noted, he has become in reality a scientist in the triumphs of the arts of horticulture.

Notwithstanding the advanced conditions of fruit breeding, scientifically considered, and the great success which attends cross-fertilization and hybridization as a means of securing new and desirable qualities, a large per cent. of our cultivated varieties, and many of them possessing the highest merit, are, and will continue to be, accidental seedlings, as will also a large proportion of seedlings grown from artificially fertilized seed prove to be worthless.

The effect upon tree or plant resulting from this process of "mending nature," which the horticulturist has been engaging in, while securing desirable improvements in their fruits, has already been hinted at. In a state of nature there existed a perfect equilibrium of forces. Then, again, each species was planted by nature in soil and climate congenial to it. Man has interfered with both; he has disturbed the one by selections and by cultivation with a given object in view, while he has sought to adapt a species, limited by nature to a small area of territory, to vast districts with greatly varying climatic conditions. Thus he has first weakened vitality by the neglect of natural qualities, and, second, he has transplanted the species into uncongenial soils and climates.

Why should we wonder, then, that our cultivated fruits are so delicate in constitution and so sensitive to the varying conditions of our fickle climate? Why should we wonder that the peach, a native of hot and arid Persia, should refuse to yield its luscious treasures on the bleak and frozen plains of the Northwest?

To treat our subject in detail and to avoid a mere compilation of descriptions of varieties of new fruits, often highly colored by self interest, the republication of which would not unfrequently prove of greatest value to introducers, would require greater practical knowledge of pomology in all its various branches and in the widely varing soils and climates of the United States than the writer presumes to possess. Hence the descriptive-catalogue plan of treatment is abandoned in favor of the more general one following:

THE APPLE (*Pyrus malus*).

Of introduced fruits the apple stands at the head. The process of improvement of this fruit, as indeed of most introduced species of fruits, has been in progress

from an early period of history, and is therefore very far removed from the original type of the species. The multiplication of desirable varieties has, however, been greatly accelerated within the period covered by American history, and largely upon American soil.

Stephen Switzer, in the *Practical Fruit Gardener*, published in London, in 1723, describes but twenty-one varieties of apples as then known to pomologists, which he, as the leading pomologist of his day, considered worthy of a place in his book. William Coxe, the first American author, in 1817, describes and illustrates by cuts one hundred and twenty-three varieties, partly of American origin, but largely from Europe, while Charles Downing, in his latest revision of his brother's work, Fruit and Fruit Trees of America, published in 1885, describes about two thousand varieties of this noble fruit. This large list of varieties, each of which possesses merit justifying this noted author in giving it a place in his cyclopedia of American pomology, is now rapidly being augmented by new and promising sorts introduced from Europe and by accidental as well as by artificial propagation, cross-breeding, and hybridization.

A great stimulus to the work of propagating and introducing new sorts of apples has its basis in the rapid decay of old and established varieties, from climatic changes, diseases, and insects, incident to the settlement of our country and its gradual conversion from a wilderness to a densely populous region. These causes have induced our enterprising pomologists to search the remotest countries of the civilized world and to encourage and foster every hope, having its origin in new varieties, to gratify a desire to re-establish this standard fruit in regions heretofore producing crops of apples, and even to adapt its culture in naturally uncongenial climates and soils.

With this commendable object in view, the great Northwest is now being filled with varieties from the steppes of Russia and their hardy iron-clad offspring, while the south of Europe and Asia are being diligently searched for such as may succeed in the warmer portions of our country. How far these efforts to reclaim and re-establish the apple industry in our land may prove entirely successful and satisfactory is at present a question only partially solved, but that progress is being made is apparent to all close observers. There is no section of the country where more persistent, and in reality where more encouraging effort is now being put forth, through the zeal and enthusiasm of local pomologists, in successfully adapting the apple through introductions from abroad and careful scientific breeding afterwards, with a view to overcoming almost insurmountable climatic conditions, than in the great Northwest. All honor and success to the public-spirited, liberal-minded, intelligent horticulturists, who are thus engaged in a work that must prove a blessing to unborn generations.

Our cultivated apples and nearly all crabs are of foreign descent, the former from the wild apple (*Pyrus malus*) and the latter from the wild crab (*P. bacata*) each of northern Europe. Improved varieties of the crab are now quite numerous, many of which are highly esteemed in the North on account of extreme hardihood of tree and fruit. It is thought by some that the Wealthy apple, of Minnesota origin, and justly popular in that severely cold climate, is an accidental cross between these two species.

THE PEAR (*Pyrus communis*).

Standing next to the apple and closely related botanically may be ranked the pear, which is also of foreign descent. It is less generally cultivated than the apple. Although Switzer describes more varieties in 1723 than he does of the apple, Downing's work does not include more than half so many. This is doubtless partially due to the fact that the pear succeeds better in Central Europe than in America. Until within recent years our catalogue of pears was largely made up of varieties of foreign origin, notably from France and the Netherlands.

During the early years of the present century a great impetus was given to pear culture, through the origin and dissemination of new and promising varieties, by Dr. Knight, of England, and Professor Van Mons, of Belgium. The methods adopted by these justly noted scientific breeders of new and improved varieties were radically different, the first consisting in cross-fertilization and hybridization, while the latter pursued the less scientific, though, in his case, quite successful, method of breeding by selections; that is, by selecting the seeds of varieties as nearly the original type as possible, but already in a state of variation, and hurrying them through generation after generation until satisfactory results were obtained. Many fine varieties, not only of pears, but also of other classes of fruits, were the direct results of the labors of these eminent gentlemen.

During the latter half of the present century many new and desirable varieties have had their origin in this country. Indeed, American varieties now largely predomi-

nate in our leading catalogues. Recent introductions of pears (like the apple and other classes of fruits) have been and are being made from Northern Europe, China, and Japan, with special objects in view; that of hardihood and freedom from disease in the North and West, and of adaptability in the more southerly portions of our country. Perhaps the best of these introductions in the South are the hybrids and cross-breeds of the Asiatic species, originating here, for which are claimed a combination of qualities, rendering them of great value south of the fortieth degree of latitude, especially for market purposes. The Keiffer and Le Conte are the most promising of these. They are acknowledged to be true hybrids between the Chinese Sand pear and varieties of the species *Pyrus communis*, combining some of the good qualities of each. The late introduction from the north of Europe and their descendants are thought by some to be especially valuable and promising above the fortieth parallel of latitude.

THE PEACH (*Persica vulgaris*).

Though a native of Persia and the south of Asia, the peach has become so fully acclimated in many sections of our country as to be justly entitled to a front rank in point of commercial value. It is very successfully grown within the modifying influence of the Great Lakes on our northern borders, also along the Atlantic and Pacific coasts as far north as the 40th degree of latitude, and throughout favored sections of the interior. Wherever peach culture is fully successful it is exceedingly profitable, and in many sections not strictly of this character the more hardy varieties, if not commercially valuable, may be grown as amateur fruits, well worthy of the care we bestow upon them.

The peach above all our cultivated fruits inclines to reproduce its like from seeds. I do not mean by this that seedlings may be relied upon to produce the same variety as that from which the seed was taken, but most likely offspring of marked family resemblance. This fact being generally known, gives rise to innumerable varieties, through the common habit, especially where peach culture is not fully successful, of trusting to seedlings, as they are generally admitted to be more hardy. Many of these might, on account of hardihood of trees and bearing qualities, prove of great value if they were propagated and disseminated, which, through neglect, are lost. In strictly peach regions, where market qualities are desirable, only budded varieties are grown to great extent.

Here we will find manifested commendable zeal in the origin and preservation of desirable varieties. The catalogues of peach nurseries vie with each other in presenting to their customers new and promising sorts. Along the Gulf coast, south of the parallel of really successful culture of ordinary varieties of peach, experiments are being made with a class of peaches introduced from eastern Asia, with encouraging results. From this source varietie sare being produced which seem to withstand the high per cent. of atmospheric humidity which prevails in that section. Of this class the Peen-to or Chinese flat peach seems to be most promising. An exchange says:

"In southern Florida the Peen-to grows to perfection, especially in the sandy soil of Orange, Polk, and Volusia Counties, where it matures fruit of fine quality before the fruit in Georgia or northern Florida is ripe. Dr. Berchmans says of this peach: 'The Peen-to, together with the Honey, succeed in Florida where the other varieties of the common or Persian strain prove of little or no value. It matures in Florida from April 15 to May 10.'"

THE NECTARINE (*P. vulgaris*, var. *lævis*).

This fruit, being at the most only a subspecies, or possibly only a variety or sport of the peach, having as its distinguishing characteristic a smooth skin, scarcely deserves special mention here. It only succeeds where the peach does, and even there often succumbs to the attacks of the curculio, which, owing to the absence of down on the skin, finds it an easy prey. Its cultivated varieties are not numerous, and perhaps there is little effort made to greatly increase the list.

THE ALMOND (*Amygdalus communis*).

Almond culture is indulged in to some extent in portions of California. Very closely related to the peach, a native of northern Africa and the mountains of Asia, it only succeeds where the peach may be profitably grown. There are a number of varieties, indeed, almost distinct species, of the almond in cultivation. This fruit, if we may apply the term to it under the strict rules of pomology, is only grown for its kernel, which is quite extensively used, both in its natural state and in confectionery. Quite a commercial business is done in almond culture in portions of California, where new and improved varieties are frequently met with. The peach,

nectarine, plum, and apricot grow readily when worked on the almond stock, indicating the existence of a close botanical relationship between the several species.

THE APRICOT (*Armeniaca vulgaris*).

Apricot culture in the United States is limited to a comparatively small area of territory, mainly the Pacific coast section. This is largely due to two causes: First, because of its blooming so early it is very liable in localities subject to late spring frosts to be killed thereby; and, second, being a smooth-skinned stone-fruit, it is very subject to the attack of curculio. For canning and evaporating purposes, as well as for use in the fresh state, it is a very profitable fruit in sections adapted to its culture. Here new and improved varieties are frequently produced. The apricot occupies an intermediate place between the plum and the peach, perhaps not being closely enough related, botanically, to hybridize with either, but having sufficient affinity for each to bud and graft successfully on both. It is a native of Southern Asia, and is largely grown in China and Japan, where it is said to be one of the most valuable fruits.

THE QUINCE (*Cydonia vulgaris*).

There are three distinct species of the quince in cultivation in the United States; the one (*C. vulgaris*) for its fruit, and the others, the Chinese and Japanese species, mainly for ornament;* the first from the city of Cydon, in Crete, and the others from the countries named. The quince is hardly an edible fruit in its natural state, though admirably adapted to preserving in various forms, especially in company with other fruit, to which it imparts a most delightful flavoring. Its cultivated varieties are not numerous, though it is very profitably grown in many sections of the country.

The Japanese species (*P. Japonica*) is quite generally cultivated throughout the North as an ornamental flowering shrub, while the Chinese, much less hardy, may frequently be met with in the South.

Each of these species often bear fruit of fair size, which, used for jellies, in connection with other fruits, imparts most delicate flavorings. There is no doubt but that further culture, with a view to the development of improved varieties, may result satisfactorily in case of these rather newly introduced species.

THE FIG (*Ficus carica*).

Fig culture, except in California, is not successful in the United States, without winter protection, north of the thirty-second degree of latitude. Owing to the overmoist atmosphere of the Gulf States, it is not grown there for commercial purposes, but in southern and central California it finds a congenial climate, where it is in many places already a staple crop. There is no doubt, also, but what its profitable culture will be extended in the near future over a large portion of Arizona, New Mexico, and Texas. The fig has been domesticated from the earliest history of man, and the country is most highly favored by nature where he may enjoy the fruits of his own "fig tree." We may not claim for this that it is a new fruit, but rather that in its numerous varieties it is "valuable" in regions where it may be successfully grown, as it is now in California.

THE POMEGRANATE (*Punica granatum*).

This singular fruit may not prove to be immediately valuable in any portion of the United States, though well worthy of notice here. Its range of latitude corresponds to that of the fig. It is a native of the south of Europe and Asia. The pomegranate is well worthy of a place in amateur collections, wherever climate and soils are adapted to its growth, if indeed it may not under such circumstances present claims upon the more strictly commercial fruit grower. Downing describes but three varieties of this fruit. In addition to its fruit, there are many varieties of pomegranates cultivated alone for ornamental purposes, they producing exquisitely beautiful flowers.

THE OLIVE (*Olea Europea*).

Olive culture in the south of Europe is a very profitable industry. The late Marshall P. Wilder is represented as saying, after an official sojourn in Europe, that "it

* The Chinese quince is highly prized in the South for its fruit, which sometimes attains two pounds in weight. It is not hardy in the Northern States.—VAN DEMAN.

plays a most important part in the domestic economy" of that country. One hundred years ago Thomas Jefferson heartily recommended its introduction into Virginia and other Southern States. Its culture, however, has not so far proved very profitable in the Atlantic and Gulf States. In portions of southern California it is now receiving careful attention, and bids fair to prove most satisfactory and remunerative. If, as the friends of olive culture in California predict, it should prove so successful there, then there doubtless are large areas in Arizona, New Mexico, and Texas where its culture must also become profitable. Let it be thoroughly tested in those regions.

THE BANANA (*Musa sapientum*).

If it should prove possible by special culture, with a view to the production of hardier varieties, to adapt or acclimate the banana within the territorial limits of the United States, even though it should be in small areas, it would be a triumph worthy of all reasonable effort. No fruit has so rapidly grown in esteem and popularity among the American people within the last few years as the banana. Scarcely a decade has passed since a car-load of bananas would have supplied for an indefinite time the markets of one of our largest cities. Now there are tons and tons of them used daily, and it is a poor market, indeed, where they may not be found at all seasons of the year. From being a luxury admired and used by the few, they are now sought for as daily food by millions. I know of no sacrifice too great, if it should only give the hope of success, for us as a people to make in order to adapt this magnificent fruit to culture in sections of our country. Let the effort be made.*

THE MEDLAR (*Mespilus Germanica*).

The medlar is a native of Europe, where it is frequently met with in its wild state. By some botanists it is considered as a member of the genus *Pyrus*, with which it certainly has close affinities as it is often propagated by budding or grafting on the pear. None of our American authors on fruit culture have deemed it worthy of notice, though in Germany and other central European states it is quite a popular fruit. The fruit, which is of fair size, is very peculiar in appearance and character, it having a dark-brownish skin and firm, austere flesh, and is said to be "only eatable after having been kept until the first stages of decay, called bletting, has thoroughly softened the flesh of the pulp. In this state the medlar is highly prized by some, who are fond of its rich subacid flavor." It is a handsome but small tree, which is often used for hedges in Europe. It is hardly probable that the medlar will ever become either popular or profitable in this country.

THE LOQUAT (*Eriobotrya Japonica*).

A related species to the above is now quite common in the Gulf States, where it is cultivated, probably more as an ornamental tree than for its fruit. The latter, however, may frequently be met with in the city markets as "Japan plum." The tree is a broad-leaved evergreen of handsome form and foliage, and with its flowers, which appear in large terminal spikes in autumn, followed in early spring by clusters of yellow fruit, may be seen in all ornamental grounds in Southern cities. The fruit has a very pleasant sub-acid flavor, and were it not subject to injury by frosts, blooming and maturing its fruit as it does, during the winter season, would probably become a popular fruit in the extreme south of the United States.

THE GUAVA (*Psidium*).

This is a small, pulpy fruit, used largely for jellies and preserves. There are a number of species in cultivation. It is fast becoming popular in Florida and portions of California, where, although a native of tropical America, it has become fully acclimated. Among newly introduced fruits it bids fair to take front rank in the semi-tropical sections of the United States.

THE PINE-APPLE (*Ananassa sativa*).

Like the guava, the pine-apple is a native of the West Indies and Central America. It is only grown successfully in southern Florida, where it is promising to prove of value.

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* It has been made and with good success in the more tropical parts of Florida.—H. E. VAN DEMAN.

THE COCOA-NUT (*Cocos nucifera*).

A native of the South Sea Islands, the product of a stately palm tree, succeeds only in the maritime districts of south Florida, where great anticipations are now based upon its probable future value.

THE DATE (*Phœnix dactylifera*).

Like the foregoing, the date is the fruit of a magnificent palm tree, a native of Northern Africa, where, next to the camel, it is the greatest blessing of that arid region. The date palm is hardier than the cocoa-nut, thriving as far north in the Gulf States as New Orleans and Mobile, but owing to the high per cent. of atmospheric humidity prevailing in that section is not fruitful. It is grown there only as an ornamental tree and it is greatly admired for its stately habits and symmetrical beauty. In southern California, however, where the climate more nearly resembles its native home, it is being introduced with great promise of success, as it will doubtless prove to be throughout the whole section of the United States bordering on Mexico.

THE ORANGE (*Citrus aurantium*).

We come now to notice the orange and its near relatives, the lemon, the citron, the lime, the shaddock, and the pomelo. At the head of the citrus family stands the orange. In our school-boy days, less than half a century since, the orange was only known in this country as a foreigner—an alien, scarcely thought to be susceptible of acclimation on American soil. It was seldom mentioned and less seldom seen, being only referred to as the type of beauty, and, in the school-room, for the purpose of illustrating the globular form of the earth. What few oranges then reached our shores were from the south of Europe and the adjacent portions of Asia, the land of its nativity, and were considered a luxury, only to be indulged in by the wealthy. The orange is now a staple fruit throughout the whole of Florida and a small portion of other Gulf States, and especially the vast areas of central and southern California. Varieties have rapidly multiplied and also great improvements have been made in modes and methods of culture, marketing, etc. Perhaps no lands within the limits of the United States have so rapidly enhanced in value for merely tillage purposes as lands adapted to orange culture. This evinces the wonderful progress being made in special sections, and the commercial value of this industry. With the rapid growth of the orange industry the spirit of improvement of varieties keeps pace, which varieties are now much finer than formerly. Fortunately for the producers, the crops of the two sections of our country adapted to orange culture do not come into competition in the markets, and therefore prices are always satisfactory, as the oranges of Florida are well off the market before those of California come in. Probably one of the most promising newly introduced varieties of the orange is the Washington Navel, which is rapidly taking the front rank, both in California and Florida, not only for merely commercial purposes, but also on account of its exquisitely fine quality. The Mandarin orange, a very peculiar variety almost amounting to a subspecies, together with its near relative the Tangierine, natives of Southeast Asia, are gaining some popularity, especially as amateur fruits in orange-growing districts.

THE LEMON (*Citrus limonium*).

Among citrus fruits the lemon ranks next in value to the orange. It is successfully grown only in south Florida and in southern California, it being somewhat more tender and susceptible of injury from frosts than the orange. Notwithstanding lemons are profitably grown in the regions named above, the industry has not, as yet, become sufficiently renumerative to justify very extensive planting of this fruit on land necessarily well adapted to the growth of the orange, which proves so much more valuable. Hence a large per cent. of lemons in this country are still imported from the south of Europe.

THE LIME (*Citrus limetta*).

This differs from the lemon, to which it is very nearly related, in the color of the flowers, which are white (those of the lemon being tinged with red), and in the smaller size of the fruit. It is also less hardy than the lemon and is restricted to a comparatively small area. The lime is more acid than the lemon, it being the source of most of the citric acid of commerce. It is also used largely in its green state for

pickling and preserving, for which it is esteemed very highly. Its culture, like that of the lemon, is so overshadowed by that of the more remunerative orange as to keep it somewhat in the back-ground as a commercial fruit. It may be found, however, in cultivation in its numerous varieties in some of the orange and lemon growing districts and may ultimately find a rank of value, especially through its manufactured products.

THE CITRON (*Citrus medica*).

It is grown to only a limited extent in the orange-growing districts of this country. Next to the shaddock, it is the largest-fruited member of its family. It belongs strictly to the lemon branch of the family, with a thick, fragrant rind, which is the portion of the fruit of value, as this, in a preserved state, enters largely into commerce, being used in confectioneries as well as for flavorings in the domestic economy. A pleasant and refreshing beverage is also made of the pulpy portion of the fruit, much resembling lemonade.

THE SHADDOCK (*Citrus accumana*).

The shaddock and the pomelo* are mammoth members of the orange branch of the citrus family which are but little cultivated, except for ornament. Trees are very handsome in form, foliage, and flower, and especially so when loaded with their magnificent orange-like fruit, which sometimes attains the enormous weight of 6 or 8 pounds. A rather pleasant beverage is often manufactured from the pulp of these fruits.

THE WILD ORANGE.

The wild orange, or bitter-sweet, of Florida and the Gulf coast, though not a native, has so long found a congenial home here as to be fully entitled to recognition as a "citizen." It is truly a handsome fruit, and, though deceptious in quality, may possibly prove valuable in the hands of the experimenter as the parent of future valuable varieties. Having escaped from cultivation in the early years of American history, it has, unrestrained, now had time to gain many desirable qualities, lost during captivity. It may therefore now be found in first-class condition for valuable and interesting experimentation. As it is, it is of great value as furnishing hardy stocks for the cultivated orange, in addition to its truly ornamental qualities of tree, flower, and fruit.

THE CHERRY (*Cerasus sylvestris* and *C. vulgaris*).

Downing separates the cherry into two classes—first, the Bigarreaus and Hearts, and second, the Dukes and Morellos. These amount almost or quite to distinct species. The cherry, excepting some native species not yet subjected to cultivation and improvement, is a native of Asia. It has been handed down to us with the improvements of many centuries of domestication. The Hearts and Bigarreaus, being strong and vigorous growing trees, are somewhat tender in many sections of our country, especially in the level, fertile West, and are therefore not so generally cultivated, though as a rule the fruit is of fine quality. According to Dr. Warder, the Hearts and Bigarreaus are not entirely reliable except on soils where the American chestnut is an indigenous growth, or at least successful when introduced. The Dukes and Morellos are more hardy and fruitful, this class embracing varieties like the Kentish, which are quite universally popular. Though in some sections a profitable fruit, the cherry has scarcely held its own in point of popularity along with other classes of fruits during the last quarter of a century. This is perhaps partly due to the overshadowing popularity of the strawberry and other small fruits coming into competition with it, by reason of their ripening at or near the same season. In some particulars, however, especially for culinary purposes, the cherry is not likely to be entirely superseded by any of its host of rivals. The late Dr. Kirtland, of Cleveland, Ohio, made the improvement of the cherry, which succeeds admirably in that section, the specialty of his life work. In this way he gave to the world a number of valuable varieties. More recently new introductions are being made from abroad, through the energy and perseverance of Professor Budd and others, with encouraging prospects. We may hope from this source to obtain varieties directly and indirectly which will prove more hardy and valuable, especially north of the present limit of cherry culture. As in-

*The pomelo is a fruit fast gaining a good reputation in the Northern markets, as well as in Florida.—H. E. VAN DEMAN.

timated above, very little, if any, effort has yet been put forth in the improvement of our native species, of which Professor Gray mentions at least four. The arts of horticulture, aided by the hand of time, may yet subjugate to the uses of man some or all of these now untamed species.

THE PLUM (*Prunus*).

We have purposely deferred notice of the plum and some other fruits which follow because of the advanced condition of improvements of their American congeners, which will now be taken up and described along with our observations on the genuses to which they may belong.

P. domesticus, to which species, with perhaps the exception of a few newly introduced varieties from the east of Asia, all our introduced varieties of the plum and their descendants belong, is thought to be a native of Asia and the south of Europe. Like all classes of foreign fruits, the plum has long been in process of improvement. There are sveral types or families of the plum, some quite distinct and very marked. Of these the Gages, the Damsons, and the so-called prunes are examples. They are doubtless the result of long and careful culture, with certain objects in view, viz, the production of varieties with given characteristics. There are sections of our country where the domestic plum succeeds admirably, and among all cultivated fruits none are more justly esteemed than it is. There was a period, back in the forties, when plum culture was quite successful, if not to say profitable, on American soil, but owing to the increasing prevalence of disease and especially of the curculio, which above all other fruits prefers the plum, the industry waned, until, generally speaking, it ran to a low ebb. For some years past, however, plum culture has been on the increase, not including some newly acquired territory, notably the Pacific slope, where it has ever been exceedingly successful and profitable. This is not so particularly the result of improvement in varieties as it is to unknown and natural causes, which are continually operating to change results either for better or for worse, although many new and valuable varieties have been added to our lists meanwhile. In the admirable climate of California, Oregon, and other transcontinental States and Territories, plum culture is rapidly becoming a profitable commercial industry. Many tons of cured prunes, equal to the best European brands, are annually produced on the Pacific coast.

Of Japanese varieties of recent introduction much is now claimed. Prominent among these may be mentioned the Kelsey, *Prunus pisardii*, and *P. Simonii*. It is not definitely determined whether these belong to distinct species or whether they may not be varieties of *P. domesticus*, modified and changed by cultivation in the strangely singular country of their nativity. While these varieties may, and doubtless will, succeed well in California and the South, they may be looked upon as probably tender in the cold North.

P. chicasa and P. Americana.—We come now to notice species which, with perhaps the exception of our native grapes, the last few years marks the greatest triumphs in the horticultural improvement of American fruits. To a doubting Thomas, the story of the parentage of our luscious peach, the melting pear, or the delicious plum, buried in the obscurity of centuries of history, into which traces of error may have crept, probably seemed to border upon the fabulous; but we are now dealing with fruits which, less than four hundred years since, were entirely unknown and unthought of by civilized man. But for man's interference we may fairly assume that the *chicasa* plum of America would to-day exist only in its true type, in which would be recognized scarcely more of variety than is visible in a flock of wild blackbirds. The arts of horticulture have already trained these wild species to sport into innumerable varieties; in time of ripening, early, late, and medium; in quality, good, bad, and indifferent; in habits of growth, tender, hardy, iron-clad, vigorous, and fruitful; in color, with almost the tints of the rainbow. Among these are many varieties which combine all the qualities of excellence and value, excepting, perhaps, mere quality of fruit, of the best varieties of *P. domesticus* and far surpassing it in point of hardihood and productiveness. The improved offspring of these two American species, mainly of the *chicasa*, may now be found in cultivation from the Gulf of Mexico on the south to Lakes Superior and Winnipeg on the north, and from ocean to ocean. It would be valueless, in this connection, to attempt to catalogue or describe the almost legion of native plums in cultivation or on trial, and many of them thoroughly established, in our country. Our rapid strides in the improvement of this fruit should greatly encourage us in efforts to domesticate other American species as yet neglected. By cross-breeding and hybridization, the latter of which is altogether possible, combinations of qualities may result which alone would prove immensely valuable to the cause of pomology.

THE GRAPE (*Vitis*).

The grape is a justly popular fruit. There are a number of distinct species under cultivation, though prior to the discovery of America there seems to have been but one, *V. vinifera*. The grape of the Eastern Hemisphere is thought to have been a native of Persia, though its early history, being almost coeval with that of man, is somewhat obscured in doubt. Ancient, medieval, and modern history, sacred as well as profane, abound in just praises of this luscious fruit. Having thus been the companion of man from an early period, the grape of the Old World may be considered one of the most thoroughly domesticated of fruits. Originating as it did near the place of man's nativity, it has followed up his civilization, marking every age of his history with its presence and its civilizing influences. This is specially true so long as civilized man was confined to the Old World. When he crossed the Atlantic, where he found a congenial home, he soon discovered that his favorite vine failed to yield its luscious treasures. Repeated efforts, based upon the highest skill known to the arts of horticulture, only resulted in failure, so far as its culture in the open air was concerned. Despair finally seized upon him and a dark and hopeless age in which grape culture upon American soil was seemingly abandoned and unknown comes about. William Coxe, in the first American work on fruits, published in 1817, does not so much as notice the grape, while Stephen Switzer's work, published almost a century earlier, in London, describes a number of varieties then highly esteemed in England. In 1845, the late A. J. Downing describes thirty-five varieties of foreign grapes as adapted to and worthy of culture under glass, while of native varieties he only mentions twelve, "which," as he says, "are accidentally improved varieties that have sprung up in the woods and fields from wild vines." These discouragements, due mainly to unfavorable climatic conditions, prevailed, with few exceptions, until the "Star of Empire" sat upon the Pacific coast, the paradise of American pomology, where the *V. vinifera* found a new and congenial home. Here the grapes of the Old World all thrive. Within the last quarter of a century grape-growing in California has almost revolutionized the grape commerce of the world, so far as the manufactured products, wine, raisins, etc., are concerned, and yet the industry seems only to have passed the stage of infancy. All the varieties of the *vinifera* species known to the south of Europe, and many of their offspring, having their origin here, flourish in the genial climate of the Pacific coast region of the United States.

Prof. George Husmann, of Napa, in a paper on the "Past, Present, and Future of Grape Growing in California," published in volume 4 of the Transactions of the American Horticultural Society, has the following comments on the progress of the grape industry in that State:

"When gold was discovered in California, during the exciting times of its early settlement, by those who flocked by thousands and tens of thousands over the plains and across the ocean to seek the glittering treasure among its hills and along its streams, but few had an idea that this land, with its rainless summers, would, in the short space of time which has since elapsed, become more famous for its golden fruit and wine than it could ever be by the glittering metal found in the depths of the earth; that its hills and plains, looking so dry and barren during the summer months, would sustain smiling vineyards and trees laden with fruit. It was generally supposed that vines and trees could only live and thrive with irrigation; that the Mission grape, first cultivated by the Jesuit fathers, which even then found its way into the mines and was readily purchased by the delvers after gold, could only reach its luscious ripeness by being freely supplied with water during the dry months. From this small beginning, at one location and one variety, what a change! Grape-growing has spread over the whole State, until its wine crop—only one of the uses to which the grape is devoted—is estimated at about 20,000,000 gallons this year. From one variety cultivated then, we have close to four hundred varieties now, and we already produce as fine wines as any country on the globe. From the few scattering small vineyards then in the State, which were irrigated several times a year, our vineyards now look down on the land from the highest tops of the mountains, and there produce their choicest fruits, without irrigation, being more secure from frost and other deleterious influences there than in the valleys. Their smiling verdure greets the eye, and is readily distinguished thousands of feet above the valleys. Our raisins are already competing with the finest London layers in the markets of the world, and our table grapes are shipped to every city and town in the Union."

As indicated above, several native species have contributed to our list of cultivated American grapes. These were found growing indigenously in different sections of the country, and were variously known as fox grape, frost grape, summer grape, winter grape, muscadine, etc., in their several localities. Leading character-

istics of these wild species were luxuriance of growth and rambling, unrestrained habits of vine, often mounting to the tops of the tallest forest trees and loading them down with their weight of foliage and fruit, which, however, was of inferior quality. We have said that there are several native species of the grape found within the limits of the United States. Prof. Asa Gray recognizes only four species (*V. labrusca*, *V. æstivalis*, *V. cordifolia*, and *V. vulpina*); the late Dr. Englemann enumerates thirteen (*V. labrusca*, *V. candicans*, *V. Carribæa*, *V. Californica*, *V. Monticola*, *V. Arizonica*, *V. æstivalis*, *V. cinerea*, *V. cordifolia*, *V. palmata*, *V. riparia*, *V. rupestris*, and *V. rotundifolia* or *vulpina*); while Prof. T. V. Munson, an eminently practical horticulturist as well as a scientific botanist, classifies them into more than twenty distinct species. This includes a number of new species recently discovered. It would seem from these differences that botany is as yet not a mathematically true science. Professor Munson admits, however, that "all botanists who have attempted the classification of the grape genus have complained of its difficulties and confusions of one form with another. Many have concluded that its so-called species are only artificial terms to indicate certain forms of considerable extent, but that in reality there is no clear separatrix." But these scientific questions have little to do with the matter in hand. It is sufficient for us to note the most wonderful developments which have been made in the improvement of American grapes within the few years intervening since the publication of Downing's original volume in 1845. At that date only twelve varieties were named, none of which are now generally cultivated (the Catawba and Norton's Virginia only having local values at this time), aside from the Scuppernong, which is strictly a Southern variety. To this list has since been added hundreds if not thousands of new varieties, many of which rival the very best foreign sorts in point of quality, with constitutional vigor and hardihood to resist the vicissitudes of our peculiar climate and our diversified soils.

There is certainly no class of cultivated fruits to which the "science of breeding" has been so successfully applied, and in which more rapid developments have been manifested, than in connection with the improvements of American grapes. The elder Downing spoke the truth when he, only forty years ago, said of American grapes that they (the then improved varieties) "have sprung up in the woods and fields from wild vines," and that "they are therefore but one remove from a wild state." He further mentions "extensive trials which are now being made by various cultivators to produce new varieties from these," closing with the prophecy, already fulfilled, that "there is little doubt that in a few years we shall have many new native sorts, combining the good qualities of the best foreign grapes with the hardiness of the indigenous ones and with also the necessary adaptation to the various soils and climates of the United States."

In the hands of such men as Underhill, Grant, Rogers, Ricketts, Moore, Caywood, Campbell, Munson, and a host of others, aided by the light of science and practical skill, there is no longer a necessity of our waiting uncertain results of "accidentally improved varieties," which shall spring "up in woods and fields from wild vines." Now (thanks to these painstaking, intelligent men), every American citizen worthy to be recognized as such may almost without effort on his part enjoy the luscious fruit of "his own vine" in some of its numerous species and varieties. There can be found in all the range of human experience and observation no more convincing evidence of the triumphs of horticultural arts than are plainly manifested in the recent and marvelously rapid progress which has been made in the complete domestication and wonderful improvements in the wild American species of the grape. Many of these are artificial hybrids and cross-breeds, combining the good qualities of one or more species of American grapes and including *V. vinifera*, which always adds qualities of excellence, although it is generally at the expense of constitutional vigor.

SMALL FRUITS.

We come now to speak of a class of fruits the popularity and importance of which are fast being recognized. Indeed, as the staple orchard fruits have, in large sections, declined, small fruits have taken their places. It is a fact which we can not ignore that the apple, especially the staple fruit of former years, is rapidly becoming unreliable, and while no other fruit is, or can ever be, an entirely satisfactory substitute for it, small fruits must to a large extent be accepted as such from sheer necessity. These causes, together with the increasing demand for such fruits in the markets, and the facility with which they are now preserved, by canning, etc., has so stimulated small-fruit culture as to have taken it from the garden and fully established it in the field, expanding the industry from being the work of the amateur

to the professional and the commercial grower, where the market statistics of the present fully entitles it to rank. This rapid expansion of the small-fruit industry has stimulated a corresponding improvement in varieties which were formerly few and inferior as compared with the present.

THE STRAWBERRY (*Fragaria*).

Among small fruits none are so universally popular and valuable as the strawberry, which, according to Downing, "is a native of the temperate latitudes of both hemispheres—of Europe, Asia, North and South America—though the species found in different parts of the world are of distinct habits and have each given rise, through cultivation, to different classes of fruit." At the time this paragraph was penned, in 1845, strawberry culture was in its earliest stages of development in America. Downing then only described thirty-six varieties, most of which were of foreign origin and belonging largely to foreign species. Our native species (*F. Virginiana*) was then found in the meadows and fields, where they became the object of much solicitation to children who brought them to market in small quantities and in even smaller sizes from their native fields where they grew uncared for and neglected of men. This then neglected species and its hybrids and cross-breeds are now the leading varieties in cultivation. There are probably no varieties of either of the three European species (*F. vesca*, *F. Colina*, and *F. elatior*), pure and unadulterated, without mixtures and crosses of one or more of the American species (*F. Virginiana* or *F. Chilliœnsis*) now in general cultivation. America may therefore be claimed as the home of the strawberry so far as valuable varieties are concerned, as it is in reality the present paradise of the industry.

The strawberry may be truthfully considered the only universal fruit of the United States, there being no section of our whole country, in any degree adapted to cultivation, where it may not be successfully and profitably grown. In the extreme South and in California, where their winters are mild and spring-like, the season of ripening is greatly prolonged, covering months of time, while to the northward the crops ripen more uniformly. These facts, together with the present facilities for distributing the crops through the aid of the railroads (the great equalizers of the age), the leading markets of all sections are supplied with this luscious and exceedingly healthy fruit for long periods. We have already referred to the rapidly increasing magnitude of the banana trade and to the great and growing grape industry, but each and all other interests of a similar character are fairly eclipsed by the still more rapid growth of the strawberry business during the last quarter of a century. As an illustration of what this business now is, the following is quoted from the address of Hon. Parker Earle, president of the American Horticultural Society, read before that organization at its late meeting in the city of Cleveland, Ohio, September, 1886:

"Thirty years ago the daily receipts of strawberries in the city of Chicago—now the second greatest fruit market in the world—could have been carried in one wagon at one load, and it would not have been a large load either. Now whole railway trains are engaged to carry the daily supply of that market, which often amounts to 300 tons, and sometimes to twice that quantity. A similar increase of supply has taken place in most of the markets of the country. The production of the Wilson strawberry was the beginning of a new era in strawberry culture, and I may add of small-fruit gardening; for all branches of the business have been stimulated and carried along by the tide of enthusiasm which has planted strawberry fields all over the continent, and covered the tables of the rich and of the poor alike with their dishes of fragrance and crimson beauty. Thirty or forty years ago it would be safe to say that all the strawberries marketed in one day in the United States could have been gathered by a force no larger than I have seen bending over the smiling rows of a single plantation. Now there are probably not less than a quarter of a million harvesters engaged in gathering this delightful fruit for market-growers. Then the season of this fruit was limited to the three or four weeks of its ripening in each locality; now, by the help of railways and refrigerator transportation, it extends over four or five months of the spring and summer, and strawberries are sometimes transported a distance equal to that from the Atlantic to the Pacific seas."

New varieties.—Of course the rapidly increasing interest in strawberry culture has resulted in the origin and dissemination of innumerable new varieties, some accidental seedlings, and others the result of careful and painstaking breeding. Generally speaking, the tendency has been towards improvement, though, of course, a large per cent. of these seedlings have proved, on trial, to be no better, if so good, as the older sorts. With the large commercial interest which the strawberry business now represents, every new-comer which bids fair to be an improvement is hailed with delight, and its praises are heralded with the flourish of trumpets by

interested parties, who, with "wind as a motor" and "cash as the objective," stand in readiness to supply the novice with plants which are to eclipse all known varieties in point of size, quality, productiveness, etc. Thousands and tens of thousands of dollars are annually expended in this way by men who, having but little practical knowledge and less skill in the business, must necessarily reap disappointment.

The origin of the Wilson, about the year 1856, near the city of Albany, N. Y., marks, as Mr. Earle has well said, "a new era in strawberry culture." Indeed, its culture has been more generally successful than any variety originated since and thoroughly tested. Its rapid introduction and almost universal success greatly stimulated strawberry-growing, especially as a commercial industry, and with it the desire upon the part of progressive growers to produce something better; for, as Pardee has said, "this fruit is so soon and so easily raised from seed that the process invites to a very attractive series of experiments." To such as have the time, means, and inclination thus to experiment, there can be no more delightful and interesting field of operation, which also promises liberal remuneration for those who are successful in the production of varieties of true worth; but the valuable advice of Mr. J. M. Smith, president of the Wisconsin Horticultural Society, to the novice of limited experience and especially of limited means should not go unheeded. He says:

"Don't be in a hurry to get these new varieties that come out and are being recommended by this man or that; wait till good reliable growers in your vicinity, or some men that you know are reliable, have tried them. You can grow varieties that will answer your purpose from those kinds now in use. If you have plenty of time and plenty of money, and like to experiment with new varieties that come along, you will find plenty of use for your time and money, and, by the way, get very little return for either."

As has frequently been intimated in this paper, the author can not safely enumerate a list of new varieties here, which are now regarded as promising, through fear of misleading the planter, since there are so many local influences which naturally affect results in strawberry growing. To the professional grower, and especially to the State or nation, truly belongs the duties of the experimenter; but to the average planter we most heartily commend the good advice of President Smith, than whom there is no safer and more thoroughly practical and successful guide in matters pertaining to the culture of the strawberry.

THE RASPBERRY (*Rubus*).

Next to the strawberry, the raspberry is probably the most valuable of the small fruits. It belongs to the same botanical genus (*Rubus*) as the blackberry. There are three species, one foreign and two native, from which our cultivated varieties are derived.

R. Idæus is a native of the mountainous districts of the south of Europe. It has long been domesticated, and, as with all Old World fruits, is much more highly developed than are the American varieties. The class of berries known as Antwerps and all their American descendants belong to this species. The size and quality of varieties belonging to this species are superior to any yet derived from our native species, but, like foreign grapes, they are not generally free from disease and other constitutional defects, and especially are they tender and subject to winter-killing in our climate and soil. In a few favored sections, notably the Hudson River region, they succeed fairly and are very justly popular, especially with amateur growers, in consideration of their fine size and excellent qualities of fruit. As with grape culture, the first efforts at raspberry culture in America were with varieties of this species, which, from causes above hinted at, were not satisfactory in results. Of fourteen varieties described by Downing in 1845, all but three were foreign sorts. The great preponderance of varieties of this species at that time in cultivation shows how great the effort to overcome climatic conditions by persistently adhering to varieties of our ancestors. The relationship between this and one of our American species (*R. strigosus*), is so close, as indicated by the habits of plant and fruit, that they readily hybridize, and thus the good qualities of the two are often blended, so that it is possible that many of our red varieties now in cultivation are the offspring of both foreign and native parents. All strictly foreign varieties, except in favored localities, must have winter protection to succeed satisfactorily in our country.

R. strigosus.—Downing's original work describes this as a variety—the American Red—and says: "It ripens nearly a week earlier than the Antwerps, bears well, and though inferior in flavor and size to these sorts, is esteemed by many persons, particularly for flavoring liquors." The writer of this could scarcely have believed that in less than forty years this almost despised species should have given us offsprings

of such value as the Turner, Brandywine, Herstine, and numerous others which now find their way to our market centers in astonishing quantities, not to be degraded by fermentation or distillation into vile liquors, but to feed the hungry and gladden the lives of the denizens of large cities. This and the foregoing species propagate themselves by underground suckers and not by the tips, as does the following:

R. occidentalis, which is a native species. Downing describes two varieties of this species in 1845—the American Black-cap and the Ohio Everbearing. Of the former he scarcely speaks more complimentary than of the American Red, saying: "This raspberry, common in almost every field, with long, rambling, purple shoots and flattened, small black berries, is everywhere known." Think of this as the parent of our Doolittle, Gregg, Hopkins, Nemaha, Schaffer, etc. Think of the tons and tons of these and numerous other offsprings of this almost despised native species that are now grown, making fortunes for their propagators and health and happiness for the denizens of our great centers of population. And how are we to predict the future of an industry so young and yet of such vast proportions? Surely cultivation has wrought wonders upon this native species in so short a time.

THE BLACKBERRY.

As above noted, this fruit belongs to the same botanical genus (*Rubus*) as the raspberry, but differing essentially from the latter in the character of its fruit, which, according to Gray, does not separate "from the juicy, prolonged receptacle." There are two species, *R. villosus* and *R. Canadensis*, both purely native, from which our cultivated varieties are derived.

R. villosus, the common high or upright blackberry, is a native throughout a large portion of the United States. Its fruit, while in a state of nature, was probably more highly developed than that of the raspberry, though it has been greatly improved by cultivation. In certain sections of the country, especially in neglected and abandoned fields, where the blackberry delights to grow, quite a business is carried on by pickers, who gather the fruit for sale. Vast quantities of this wild fruit finds its way into the markets, thus supplying at once a source of income to many poor people and cheap health-giving food to consumers. While this wild fruit is vastly inferior to the cultivated varieties, it serves, as above indicated, valuable purposes in the domestic economy, especially of the poor, while materially affecting the prices of the better qualities of fruit coming into competition. It is only of very recent years that any systematic efforts at improving this fruit has been attempted, but in this short time very marked progess has been made. Downing's original work does not describe any varieties of the blackberry, only mentioning the two species as they then existed, while in his more recent revision he describes twenty-five distinct sorts, and many more have since appeared. Some of these are so manifestly better than were the wild varieties as to already have won for themselves places of front rank, in point of commercial value, among cultivated fruits. The writer has in mind a crop of the past season in which a single picker gathered forty-two gallons in one day, so abundant was the fruit. This was of one of the present leading varieties, the plants having been thoroughly cultivated, and the fruit going to market in such shape as to bring remunerative returns for the painstaking intelligence bestowed in the selection of the variety and the culture following. With the native plum, grape, strawberry, raspberry, and other fruits our success in improving the native blackberry should encourage us to look more hopefully upon our prospects of greater achievements with various American species not yet subjected to the ameliorating influences of horticultural arts.

R. Canadensis, the low or trailing blackberry—the dewberry—like the foregoing, is a native. It is not so frequently met with as the blackberry, being confined in its native habitat more strictly to hill regions. The fruit differs but slightly from the latter. There are a number of cultivated varieties of this fruit now grown, some of which exhibit qualities of merit. Among such the Lucretia probably stands in the front rank as a promising sort.

THE CURRANT (*Ribes rubrum*).

The currant is a small fruit of some importance. Our cultivated varieties belong to the above species and are native of the north of Europe. It succeeds best in a rather humid soil and atmosphere. Like its near relative, the gooseberry, it is a very popular fruit in Great Britain and the north of Europe, where the climate is well adapted to its culture. Several imported insects (the currant caterpillar and the borer) have of late years seriously affected the culture of the currant in most sections of the country, though scarcely any American garden is thought to be com-

plete without its supply, for domestic uses at least. These usually occupy some obscure corner in the garden, where they, if not too seriously injured by insects and the like, produce satisfactory crops, and are a favorite in the kitchen for pies, jellies, etc. Downing says, in speaking of the currant in its wild state in Northern Europe: "The fruit of the original species is small and very sour, but the large garden sorts produced by cultivation and for which we are chiefly indebted to the Dutch gardeners, are large and of more agreeable subacid flavor." From the scientific name of this species (*Rubrum*), we should infer that the original currant was of a reddish color; but numerous varieties introduced by cultivation are light-colored, if not white. The white varieties, as a rule (if not invariably), are less acid than the colored sorts, which, indeed, seems to be true of all albinos among small fruits of whatever species. There are a number of native species of the currant, but none have yet been generally domesticated, at least have not become sufficiently improved to entitle them to prominent rank among cultivated fruits.

THE GOOSEBERRY.

Like its near relative, the currant, the species (*Ribes glossularia*) is a native in the north of Europe, where, and also especially in England, it has long been a very popular fruit, having reached a high state of improvement. Our climate does not suit it so well as that of England, as, like some other foreign species, it is not entirely healthy here, it being subject to mildew and disease. There are a number of American species, but until within comparatively recent years all efforts at the culture of this fruit in the United States have been with the foreign improved sorts, which have generally proved a source of disappointment. Downing, in 1845, in speaking of the gooseberry as a foreign fruit, says, "Our native species has never been improved by garden culture." Since that date, however, its improvement has been taken up, somewhat as was that of the native grape, plum, raspberry, etc., as a matter of self defense against total failure, and wonderful and most satisfactory results have followed.

R. hirtellum, the native species from which our valuable varieties, like Houghton, Downing, etc., are derived, is found growing indigenously in the northern sections of the United States. Its improved varieties (though not recognized in 1845) have already fairly eclipsed all purely foreign sorts, except in the hands of a few amateurs in favored sections, and were it not for the depredations of the currant caterpillar, which is a serious pest to this fruit as well as the currant, the culture of the gooseberry would prove exceedingly profitable. Improved varieties are already numerous and of quality scarcely inferior to foreign sorts, but as yet not cultivated up to the enormous size of some of their European relatives. They are, however, immensely productive, and for culinary purposes as a pleasant acid fruit stand second only to the cranberry.

THE CRANBERRY (*Vaccinium macrocarpum*).

This species of the cranberry is a purely native one and to it belongs all the really valuable varieties in cultivation in this country. Prior to about 1840 no attention was given to the culture of the cranberry in the United States, the native wild fruit from the peaty bogs on our northern borders supplying all market demands. The first efforts at improving and cultivating the cranberry were made on Cape Cod, where the industry has grown to immense proportions. Andrew S. Fuller, in his "Small Fruit Culturist," published in 1867, in speaking of the growth of cranberry culture in portions of Massachusetts, Connecticut, and New Jersey, says: "Not only have individuals turned their attention to it, but companies have been formed with abundant means to cultivate the cranberry upon an extensive scale." P. M. Augur, of Connecticut, says the cranberry "occupies a niche by itself, crowding out no other fruit;" that is to say, it "thrives best where no other fruit will grow." Its native habitat is in the swamps and bogs of the northern section of the United States, and it can only be successfully grown where the ground may be artificially flooded with fresh water at certain seasons of the year—at the blooming season, to protect the blooms from injury by spring frosts and for the winter protection of the plants. Where such lands can be had, with an abundant supply of water under perfect control, to be turned on or off as need be, from 50 to 200 bushels per acre may be produced with great certainty, which sell readily for remunerative prices. J. S. Stickney, of Wisconsin, estimates the annual value of the cranberry crop of that State at from $300,000 to $500,000. Since the attention of the fruit-grower has been turned toward the culture of this fruit, numerous improved varieties have been brought into notice. Downing says "the value of the common

cranberry for tarts, preserves, and other culinary uses is well known." The cranberry is the last of the small fruits to ripen, thus prolonging the season of this class of fruits in a fresh state to midwinter or even later, and as it may be grown, as above indicated, on land wholly unfit for the production of other garden crops it may be fairly entitled to our favorable consideration and esteem.

THE HUCKLEBERRY (*V. corymbosum*).

The huckleberries, purely native species, belong, as above indicated, to the same botanical genus as do the cranberries. There are many species of this fruit found, both in the swamp and hill regions, along our northern borders. Perhaps the best of these is that under consideration. According to Fuller, as late as 1867 very little had been done by way of improving the huckleberry. He says: "Time and again have I endeavored to direct the attention of small-fruit culturists to the long-neglected huckleberry, but with no apparent good results;" adding further, "why this neglect I am at a loss to understand, for the huckleberry possesses naturally better qualities than even the currant or gooseberry." Notwithstanding this criticism, coupled with the high indorsement of the naturally good qualities of the species, I am not aware that any great progress has since been made in the way of domesticating and improving the huckleberry. Having noted the wonderful progress already made by way of improving many of our native fruits, we are still at a loss to know, as Mr. Fuller has well said, "why this neglect" of a species so promising and really so valuable in its native state, for the wild huckleberry is a source of great commercial value wherever it naturally grows. That the huckleberry is destined to become a domestic fruit of no inconsiderable value I have no doubt, but it may take time and patient skill to produce the necessary improvements, to adapt it to profitable garden culture. It is said that "the baboons of Africa are fond of fire, and they are said to gather and sit around an abandoned camp fire till the last ember is out, but they haven't quite sense enough to poke the brands together to keep the fire alive." Shall we, with like lack of foresight, permit this valuable native species to longer exist without applying to it the persuasive arts of horticulture?

THE BARBERRY (*Berberis vulgaris*).

There is probably little to be expected by way of improvement that may be made in this fruit, which, according to Downing, is indigenous to the north temperate zone of both hemispheres. He, however, devotes a short chapter to its consideration, saying while it is "too acid to eat, it makes an agreeable preserve and jelly, and an ornamental pickle for garnishing some dishes." Fuller gives it more attention, describing a number of varieties and claiming for the species great susceptibility of improvement, and thinks it "might, if a proper amount of care were bestowed upon it, become a fruit of much importance."

THE JUNE-BERRY (*Amalanchier Canadensis*).

Dr. Gray says this native species "varies exceedingly." It ranges in its various subspecies from a low shrub not larger than the currant bush to an arboreous form. It is strange that this native fruit, which is strictly pomaceous, being closely allied to the genus *Pyrus*, has neither received notice by Fuller, Downing, nor any other American author. The large species is a really handsome tree, well worthy of a place as an ornamental if not as a fruit-bearing species. The fruit, which is small and berry-like, is of a purplish red color, ripening in June, hence the common name of June-berry by which it is frequently known. It has a pleasant acid flavor, and is especially attractive to children and birds. I am not aware that any attempt has been made to improve by cultivation the tree-like form of the species, but in case of the dwarf forms some advance has been made by way of subjecting them to garden culture and with quite satisfactory results. There is really much in this fruit to encourage the experimenter in the work of domesticating and improving the species.

THE BUFFALO BERRY (*Shepherdia argentea*).

Fuller, in his Treatise on Small Fruits, has considered the *Shepherdia* worthy of a somewhat lengthy notice. He says: "It is seldom seen in cultivation, but it is really deserving of a place in every garden." It is a native shrub or small tree found growing wild in Dakota and in the headwaters of the Missouri River. It is doubtless extremely hardy and if sufficiently fruitful, as Fuller indicates it to be,

with other good qualities which he ascribes to it, it is a matter of surprise that it has not been more extensively cultivated. The plant itself is quite ornamental, and it certainly deserves further trial, especially in the cold Northwest.

THE BLACK HAW (*Viburnum prunifolium*).

Here is a hardy native species of pleasant, edible fruit which remains wholly neglected, so far as any effort as to its culture and improvement is concerned. It is the berry-like fruit of a small tree or shrub found growing wild in thickets of the northern section of the United States, from New England to Kansas, and is highly prized by boys (who are always good judges) and numerous wild animals, and especially birds. What its future value may prove to be in the hands of the skillful horticulturist remains for coming generations to decide. That other fruits of scarcely more natural promise have been greatly improved and rendered valuable history attests.

THE TREE CRANBERRY (*Viburnum opulus*).

Notwithstanding the common name of this fruit, it is in no way related to the true cranberries, but is a member of the same botanical family as the preceding species. Its common name is due to the fact of its slight resemblance in fruit, both in its exterior appearance and to its sprightly acid flavor, and for which it is sometimes used as a substitute in the kitchen. It has also been well used and for many years, by enterprising nursery agents, as "bait for gudgeons," who are made to believe that they may raise their own cranberries on land certainly not adapted to the culture of the true cranberry. In this way the species has been pretty largely disseminated, but in the hands of men who were not likely to bring out its good qualities, if it should (which is quite probable) possess any such. It is a native shrub found growing wild in the Alleghany Mountains. The well-known snowball is a very close European relative of this species, and has long been cultivated for its conspicuous flowers, which has thus become entirely sterile. Whether the tree cranberry (?) shall prove worthy of this notice or not, the above remarks may serve to place it in its true light and to guard the innocent and otherwise uninformed against imposition through misrepresentation.

THE ELDERBERRY (*Sambucus Canadensis*).

My early recollections are associated with elderberry pies and jellies, prepared from the fruits which we children gathered along the fence rows in neglected fields. The quality was greatly heightened, as our good mother assured us, by an admixture of the sprightly acid juice of the wild grapes which we industriously sought for the purpose. Of more recent years, when cultivated fruits were scarce, we have found in this neglected species a valuable source of table comforts and health-giving luxury. The elderberry is also often used as a source of manufacture of domestic wines, which are supposed to possess valuable medicinal properties. The fruit of different plants are known to differ widely in a state of nature, some being very much more fruitful as well as superior in size and quality to that of others. This fact should encourage the horticulturist in the selection and culture of this fruit, which, everywhere in neglected corners and hedge rows, persistently pushes its claims to our notice. It is also a great source of food supply to a large number of our feathered friends, which alone should entitle it to our consideration. Let the elderberry be considered as entitled to a place in our list of small fruits, if we do here place it almost at the bottom of our list.

THE MULBERRY (*Morus*).

Downing honors the mulberry with a brief notice, describing at least three varieties, all perhaps belonging, directly or by hybridization, to the Adriatic species (*M. nigra*), which he represents as a fine fruit, but generally too tender for our climate. He describes the tree as small, seldom attaining a "height of more than 12 or 15 feet." Of recent years a class of mulberries, probably of a different species, have been introduced from Russia, concerning which much has been said by way of praise, both as a fruit-bearing tree of great hardihood as well as a forest tree, having specially desirable qualities for retimbering the plains of the Northwest. It may probably be well to take some of these representations with a few grains of allowance, as they are likely to prove to be exaggerations.

M. rubra is a native species, which Downing says is "more or less common in our woods; the fruit is about an inch long, and very pleasant and palatable though much inferior to the Black English. It bears transplanting well, or is easily raised from the seed, and may undoubtedly be improved by repeated reproductions in this way." The native mulberry is quite common in "rich woods from New England to Kansas," forming a handsome, fair-sized forest tree, the wood of which is exceedingly durable for posts, cross-ties, etc. The fruit differs very greatly on different trees, showing a natural disposition to sport into varieties, which is of itself encouraging to the experimenter. The mulberry is certainly worthy of notice in a paper like this, both on account of its present as well as its prospective value.

THE PAPAW (*Asimina triloba*).

It is indeed strange that no American author on fruit culture has considered the papaw worthy of notice. While it is true that few persons naturally like the papaw with its peculiar flavor, it is equally true that but few fail to acquire a taste for it by repeated efforts. It is a native throughout large sections of the United States, as Dr. Gray says, from "western New York, Pennsylvania to Illinois, and southward." In its native habitat it has many admirers, especially among the boys, who are sure to hold the whereabouts of the best varieties in sacred remembrance. A papaw grove is a sure index of the good qualities of the soil, which has led the farmers to destroy many of the best of these for the purpose of getting the land ready for cultivation in other and better-paying crops. This process of destruction has been carried to an extent which already threatens the extermination of the species, unless it is soon taken up by the horticulturist—which it certainly deserves to be—and adopted into our gardens. The American Cyclopedia, which is about the only authority which I can find, outside of botanical text-books, which stops to notice this fruit, well says, in speaking of its worth, that "some trees produce in the wild state fruit of superior size and excellence, and doubtless it could be greatly improved by selection and cultivation." The writer fully concurs in this opinion, and he trusts that this neglect of so promising a native species may not long continue.

THE PERSIMMON (*Diospyros Virginiana*).

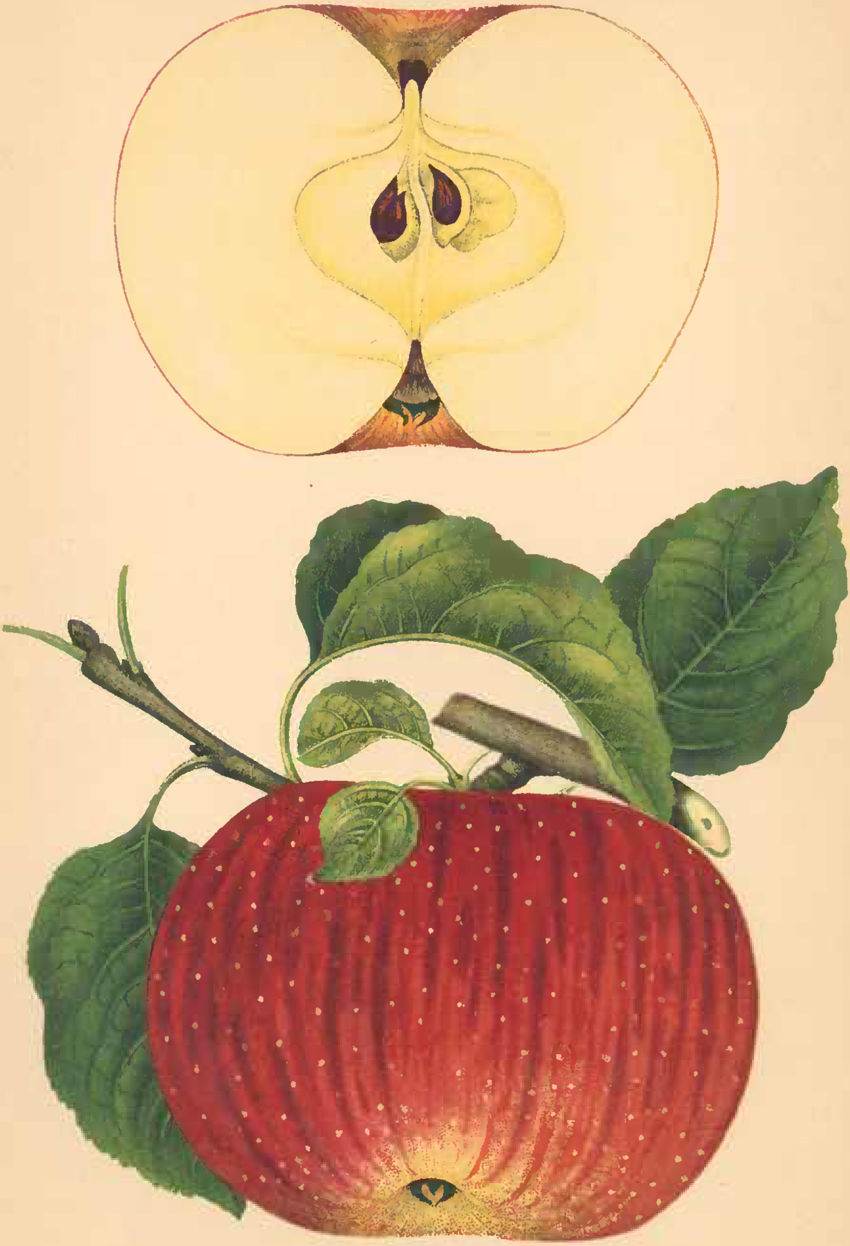
Here is another native species of even greater promise than the papaw, which has been almost entirely neglected. The persimmon is found wild in a number of the older States of the Union, from Florida to Arkansas, and northward to the fortieth degree of latitude. In large sections of this vast territory it constitutes a considerable part of the living of the poorer classes, besides being enjoyed by the well-to-do in life; while animals and birds, domestic and wild, of almost all descriptions hail the ripening of the persimmon with evident satisfaction. It grows along the fence rows, in neglected corners, and in abandoned and worn-out fields, and with the persistence of the native blackberry forces itself upon us, and with its luscious products everywhere claims our attention. It further encourages us by its disposition to sport into varieties, some of which greatly excel others in good qualities. Perhaps no native fruit of the equal of the persimmon in good and promising qualities has been so neglected. American horticulturists must not longer pass by this valuable species.

THE JAPANESE PERSIMMON (*D. kaki*).

To further warrant us in the undertaking, we have of recent years received from Japan the Asiatic relative of our persimmon, which, by that painstaking people, has already reached a high state of development. There are a number of varieties of Japan persimmon, which is a truly magnificent fruit, already in bearing in California and the Gulf States, where it flourishes, and where it bids fair soon to become both popular and valuable. This fruit is so thoroughly domesticated and so highly bred, having received centuries of careful culture, as may be shown by its immense size, fine qualities, and in some varieties the entire elimination of all seeds, and is so closely related to our native species as to readily hybridize with it, which is satisfactory proof of the probable susceptibility of the latter of similar improvement. It is claimed that valuable hybrids are already in existence, which adds to the hope of thus securing varieties of sufficient hardihood to render their culture possible much farther north than the present limit of culture of the Japan species,

CONCLUDING REMARKS.

We have now hastily noticed each of the fruits, native and introduced, which are grown to any great extent in the United States. In the preparation of this paper I have been wonderfully impressed with the growing importance of our native species of fruits. Many of these are peculiarly American, while others have their foreign relatives, which have been introduced from abroad. Among the latter may be mentioned the plum, grape, strawberry, raspberry, gooseberry, cranberry, mulberry, huckleberry, and the persimmon. While the native species have, perhaps, in no instance reached the degree of excellence of fruit to which their foreign relatives have attained through the long years of careful training which they have been subjected to, it is nevertheless true that in point of hardihood and constitutional vigor of fruit and plant that they compare favorably, if, in reality, they do not generally excel. The blackberry, huckleberry, service, and papaw are distinctively American species, and although some of these have not been domesticated, our success in improving our native fruits should prompt us to keep in mind the work so well begun, and which has given us such satisfactory results.



JEFFRIES.

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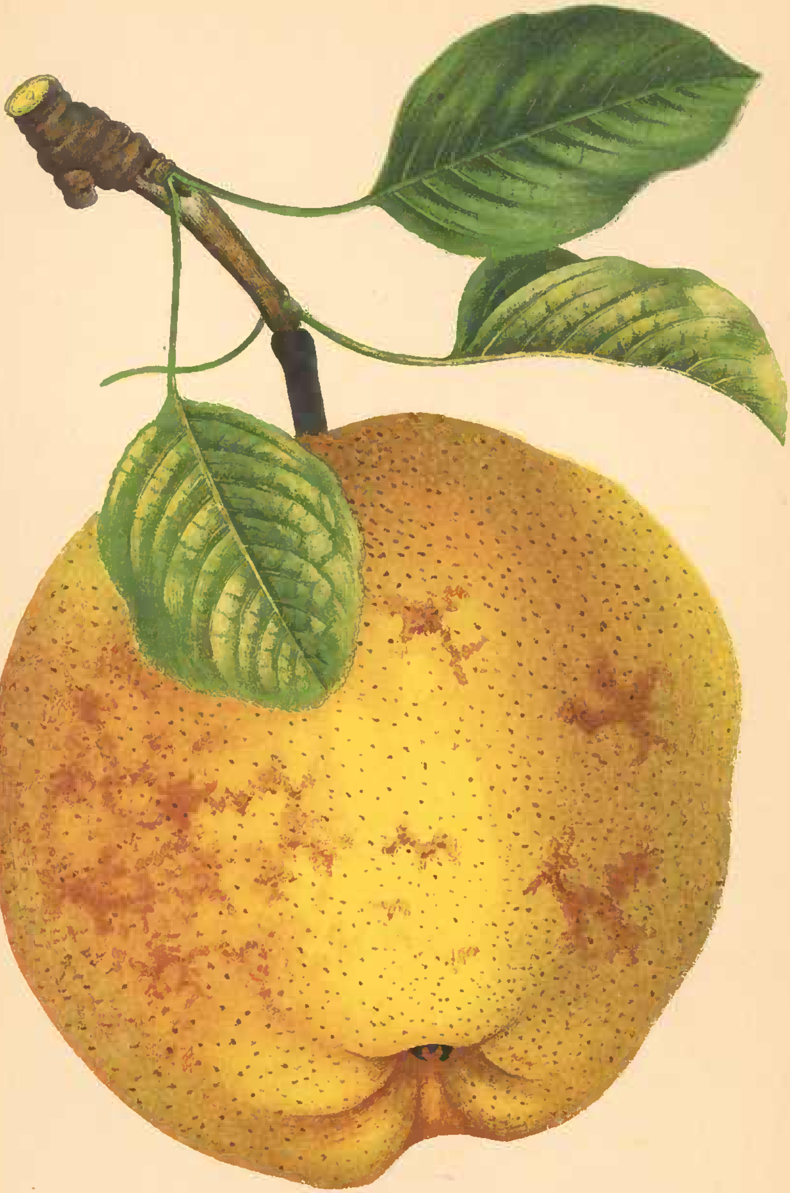

IDAHO.

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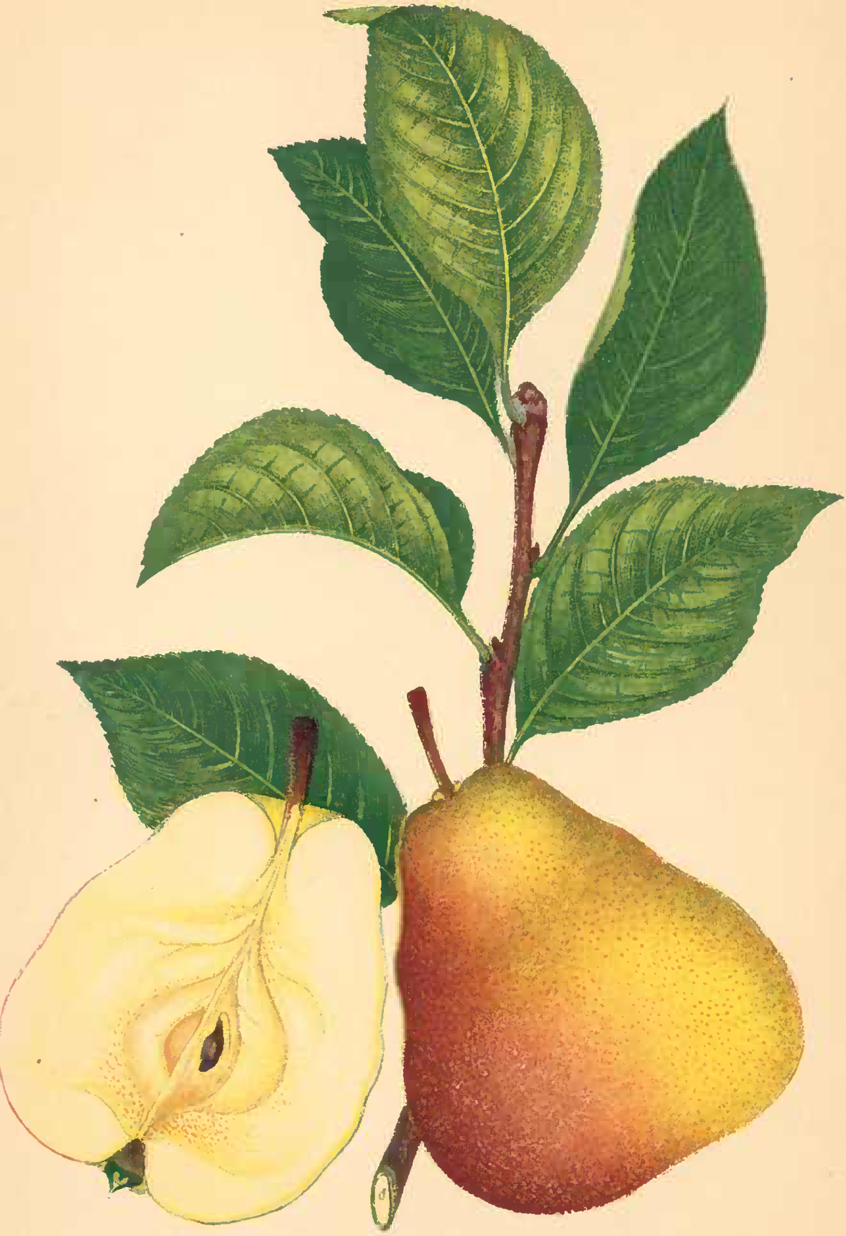

WILDER.

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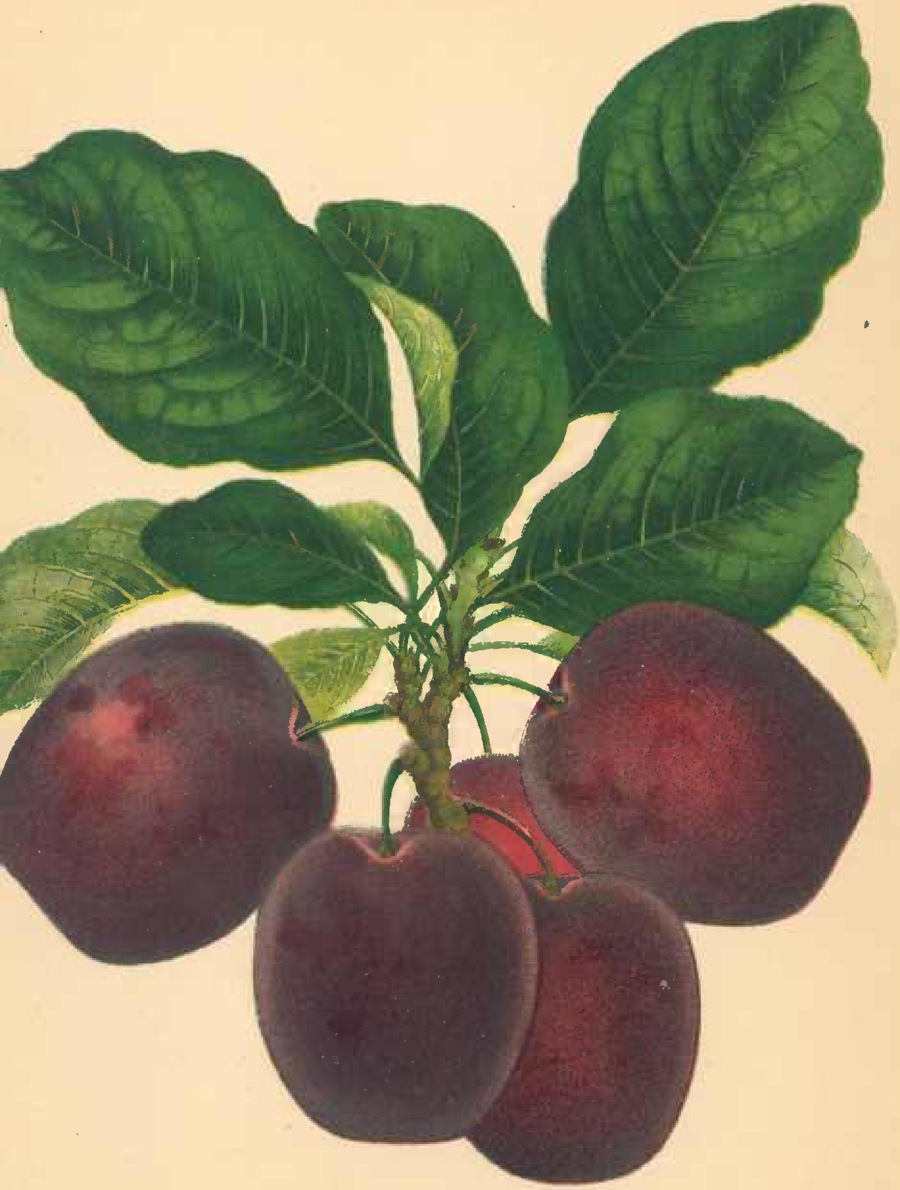

CLYMAN.

Wm H Prestele, Fecit. A. Hoen & Co Lithocaustic Baltimore

WAYLAND.

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BIDWELLS EARLY.

Wm H. Prestele, Fecit.

A. Hoen & Co. Lithocaustic, Baltimore.

DWARF JUNEBERRY. VAR. "SUCCESS"
(AMELANCHIER OBLONGIFOLIA)

Wm H Prestele, Fecit.

A. Hoen & Co. Lithocaustic Baltimore

PEPINO.
SOLANUM GUATAMALENSE.

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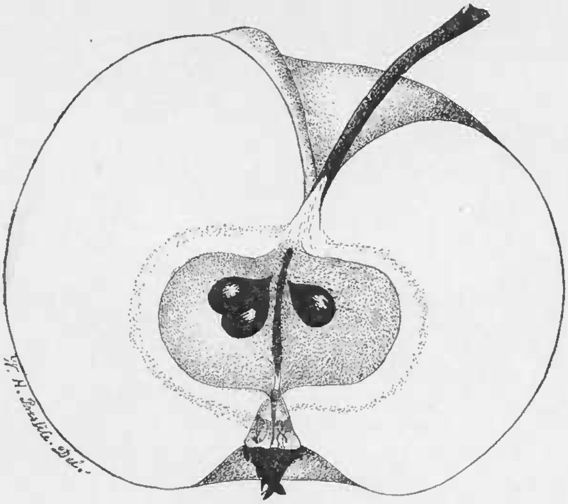

Fig. 1.

BOROVINKA.—No. 245.

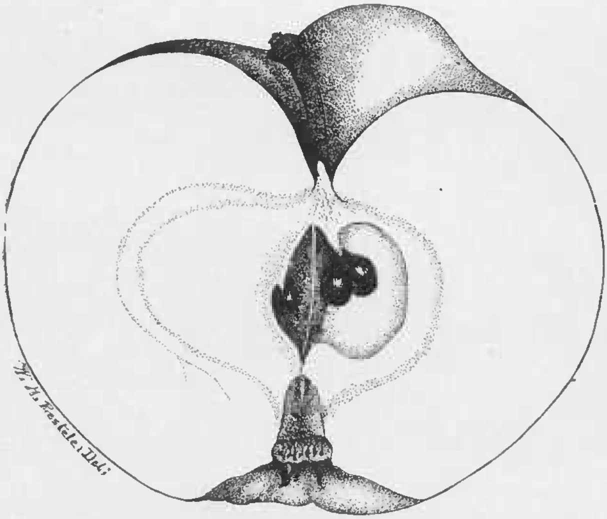

Fig. 2.

PROLIFIC SWEETING.—No. 351.

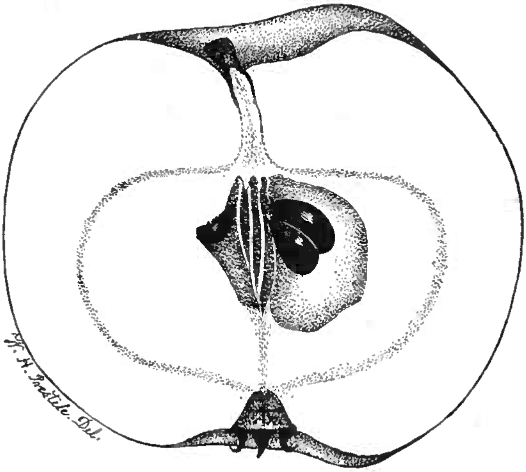

Fig. 1.

ZOLOTOREFF.—NO. 275.

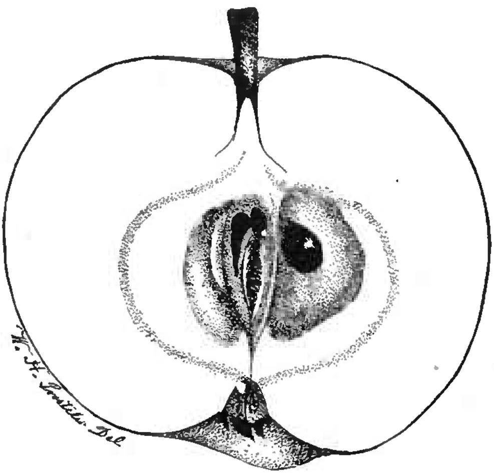

Fig. 2.

RED TRANSPARENT.—NO. 333.

REPORT OF THE CHIEF OF FORESTRY DIVISION.

SIR: I have the honor herewith to submit my third annual report on the work of the Forestry Division. In proportion to the provisions for this work, which have been measured as scantily as usual, the lines of investigation, commenced the year before, have advanced satisfactorily though slowly. No new lines of investigation have been begun, since limitation and not expansion is dictated by the appropriations granted by Congress.

It will be useless to call for "practical" work—whatever may be meant by this term—until adequate means are provided for such. The only possible practical work of this kind which directly encourages reforesting and which the Division, as at present equipped, might perform, namely, the distribution of plant material, had been attempted the year before on a novel and well-working plan, but had to be abandoned because with the funds at disposal this year no satisfactory arrangements in that direction could be made.

DISTRIBUTION OF PLANT MATERIAL.

I have dealt in my last report to you on the desirability of this method of encouragement, if carried out in a proper manner and in adequate proportions; and I may add, that distribution of plant material for agricultural and for forest planting differs in principle as well as in object. While seed distribution in the first case may be desirable for the purpose of introducing new kinds and improving the nature of agricultural crops, the distribution of forest plant material has a different object in view. It has less to do with the introduction of new kinds than with inducing the planting of a crop which without some special inducement would not be planted at all, while its existence and propagation is desirable for the community at large for several reasons. In our country especially, where immediate returns from an investment are more frequently looked for than in older countries and where the practice of forest planting and forest management is not yet established, this kind of encouragement seems quite legitimate, and if carried out on a judicious plan appears the only means for the General Government directly and practically to advance the practice.

In other countries, monarchical and republican in their constitution, this aid to forest industry is employed on a large scale and with great success. Not only do State and county governments resort to it, but societies and even private estate holders consider it within their sphere, and a proper direction of their funds and activity, to furnish plant material either free of cost or at nominal prices. I have given some statistics of this kind of forestry work in my last report and may add the following data, to impress not only the evident desira-

bility of plant distribution but also to give an idea of the extent to which it must be carried in order to be effective:

In Bohemia (area, 20,000 square miles; inhabitants, 5,500,000) during the year 1887 were distributed to communities and small farmers by the council of agriculture 754 pounds of conifer and 152 pounds of deciduous-leaved tree seeds; by estate holders, 1,408,100 conifer plants, 12,450 broad-leaved plants, and 488 pounds of conifer seeds; by nurseries, with Government aid, 1,972,908 conifer plants; or altogether the free distribution amounted to 3,393,450 plants and 1,494 pounds of seed. In the spring season of 1888 these distributions amounted to 1,441,000 plants and 1,590 pounds of seed. The Society of Agriculturists also distributed to the members of the County Agricultural Society of Tepel 12,000 plants. The Bohemian Forestry Association has during the last thirteen years distributed 24,970,987 tree plants and 9,180 pounds of seed, partly free of charge and partly at nominal prices.

In Switzerland (area, 16,000 square miles; inhabitants, 2,700,000) during 1887 there were over 5,650,000 plants and 1,550 pounds of seed distributed, the council appropriating also $26,000 towards reforestation.

In Mæhren, Austria (area, 8,600 square miles; inhabitants, 2,200,000), during the spring of 1888, the government (state and county) distributed 5,954,584 plants; nurseries and estate holders, 1,769,000 plants; so that, as in the year before, nearly 8,000,000 seedlings were given to the small farmers.

In South Australia, a country situated very much like our own Western prairies and plains in regard to climatic and forest conditions, the forest department for several years past distributed large amounts of plant material with the greatest success, as I have more fully shown in my last report.

On this occasion I should not omit to express the obligations of the Department to the forest conservator of South Australia, Mr. John Ednie Brown, who very courteously furnished to the Department, free of charge, several hundred pounds of acacia seed for distribution in the southern parts of the country. It is also gratifying to note in this connection that the tree seeds, a few packages of which the Department was able to send from its stock in return for this courtesy, are reported as germinating very satisfactorily, showing that the complaints occasionally received in regard to the quality of the seeds are chargeable to the inappropriate handling of the same. The Department is also under obligations to Heinrich Ritter von Manner, a prominent grower of osiers in Austria, for a most valuable collection of some sixty varieties of osier, sent gratuitously. The cuttings were distributed among the State experiment stations for the purpose of testing the adaptability of the various basket willows to the different sections of our country. The results of this experiment have not yet been collected.

FORESTRY INTERESTS IN THE STATES.

During the past year it seems that the interest in forestry matters has not only grown more rapidly than before, but is taking practical shape in every part of the country. I have before me reports by the State Board of Forestry of California, by the Forest Commissioner of Colorado, by the Forest Commission of Michigan, by the Forestry Bureau of Ohio, by the Forest Commission of New York.

All of these documents exhibit an advance over the same kind of literature in former years, by becoming more definite in their contents and recommendations, and discussing directly questions of local forestry interest.

Since it is still the office of this Division to aid in bringing about a general appreciation of the objects of forestry, I consider it proper in this place to call special attention to the work of these commissions and to briefly review their reports.

California.—The second biennial report of the California State Board of Forestry constitutes a volume of nearly 200 pages. It is, perhaps, the most important and valuable report yet made by any State forestry board in this country. It is illustrated by twenty-four autotype representations of the characteristic conifers of California and contains six county forest maps, in continuation of similar maps in the previous report, which by shadings and appropriate marks and figures indicate at a glance the forest condition of the counties, the kinds of trees growing on each section of land, and the comparative density of growth.

The first third of the report is occupied with an account of the work of the commissioners during the last two years. One of their principal endeavors has been to effect a reform in the method of cutting the public forests both of the State and of the General Government. These had hitherto been greatly damaged and wasted by persons cutting timber wherever they could find it, without having secured any title to it by purchase. The action of the commissioners in exposing the extent of these trespasses and aiding to bring the depredators to punishment has had the effect of increasing the purchase of the timber lands, with a consequent decrease of unlawful cutting, and at the same time a more careful and economical method of lumbering. The timber entries during the year 1887 and the first third of the year 1888 constituted about one-third of all the timber entries hitherto made in the State. Many of the lumbermen are now adopting a conservative management which contemplates the continuance of the forests as a permanent source of supply and revenue instead of their being exhausted by a single cutting and then abandoned.

By posting in the mountains and wooded portions of the State warning notices, calling attention to the law against setting forest fires, and by the activity of agents of the board in securing evidence against setters of fire, the extent of forest fires has been much lessened. The commissioners estimate that more than ten times the cost of the protective service has thus been saved to the State.

The commissioners have not only endeavored to secure a conservative management of existing forests, but also to induce the planting of bodies of trees in places where they are deficient, and where the native flora is of but little value, by distributing plant material of trees not indigenous to the State. Among these are the catalpa and locust and some of the eucalypts from Australia, and also acacias furnished by this Department. Experiment stations have been established in the different climatic belts of the State, for the purpose of testing the growth of various kinds of trees, and thus ascertaining their desirableness and their adaptation to various situations. The generosity of individuals has made up for the lack of funds at the disposal of the commissioners, by the liberal gift of lands for experiment stations of the value of from seventy-five to a hundred thousand dollars. While testing the quality of trees at these stations, the commissioners have endeavored, by planting the stations in park form, to cultivate the taste of the people and encourage the production of beautiful as well as useful results by tree-planting.

Following the establishment of experiment stations for the purposes of practical forestry, the commissioners began last year the work of supplying a scientific and popular description of the forest trees of California. The larger part of the present report gives the result of this work, so far as relates to the pine trees of the State, which include the pines of the Pacific slope. The description of these trees by the botanist of the commission, Mr. J. G. Lemmon, and the well-executed autotype illustrations of the trees as they stand and also of branches and fruit, make a publication of a very interesting character and of permanent value.*

Colorado.—The biennial report of the forest commissioner of Colorado has been recently issued. One of the most valuable features is a forest map of the State, prepared by the commissioner with much care. It shows the drainage system of Colorado and the approximate location and extent of its forest and irrigated lands, as well as the intimate connection existing between the forests, streams, and irri-

* As this report goes to press it is learned that the energetic and efficient Board of Forest Commissioners, with Mr. Abbot Kinney as chairman, has had to make room for new appointees.

gation systems of the State. This map and the report as a whole should be of great service to the people of Colorado. It contains brief accounts of the native trees, and a statement in condensed form, by counties, of the forest conditions of the State. It shows what agencies are at work to destroy the forests, what means are now used for their preservation, and what further action by individuals and by the State and General Governments is needed for this purpose.

The report shows that the commissioner has been diligent in discharging the duties of his office. In addition to the compilation of the forest map, he has done much by means of circulars and other publications to extend information through the State in regard to the value of the forests and the necessity of preserving them. The great and unnecessary injuries inflicted by forest fires have been set forth. Public meetings have been held in various parts of the State for the purpose of discussing the forestry question in its local bearings. A greatly improved public opinion has already become manifest, which encourages the forest officers in the discharge of their duties, and is preparing the way for more advanced and effective legislation in behalf of the forests. Such legislation, in various particulars, is suggested briefly at the close of the report. The legislature of the State, at its last session, authorized the establishment of four forest experiment stations, in accordance with the provisions of the bill for that purpose which was passed by the last Congress. Two of these stations have been located already by the State Board of Agriculture, and a third will be located very soon.

Michigan.—The first report of the forestry commission of this State was published at the close of the year 1888. The commission was established by act of the legislature, in June, 1887, and organized in October of the same year, for the purpose of furnishing information necessary for the basis of legislation. The commissioners think that the prevention of forest fires is the most important subject for consideration in Michigan at the present time, and the principal work done by the commission during the first year seems to have been that of seeking information, by means of circulars, in regard to the extent and character of the forests in the several townships of the State and the extent of fires among them, the causes of the fires, and the methods of preventing and checking them which have been found most effective. The report contains some illustrations showing the effect of fires in retarding, if not entirely destroying, the after-growth of the forests. It contains, also, a list of the trees indigenous to Michigan, with brief description of their qualities and practical uses. One thousand lumber mills are reported, with a capital of $48,000,000 and a product of $60,000,000 in value, with a working force of 35,000.

New York.—The details of the report by the State Forestry Commission show a distressing condition of affairs, in so far as much of the land, which had lapsed to the State for nonpayment of taxes and forms the basis for the work of the commission, is now being redeemed at nominal prices and passes out of the control of the State, by whose action in the matter of forest preservation it has become valuable.

The forest commissioners urge the enactment of a law for the examination of claims in redemption, and redemption to be permitted only to actual occupant.

They also advocate the amalgamation of the game-protection and forest-protection service, which now requires two sets of officers. They dilate upon the difficulty of bringing timber thieves and incendiaries to justice under present laws of venue. As is only reasonable, they demand for the State the right to sell the old timber and bark, the purchase of wild forest lands, the power to lease small parcels to private individuals for residence, the exclusion of railways from State forest lands, etc.

Altogether, it seems that the State of New York, with the best opportunity for demonstrating a successful management of forest lands, loses this opportunity by inadequate legislation, which handicaps the executive in carrying out the spirit of the legislation.

Ohio.—The State of Ohio owning no forests or land adapted to forestry purposes, the forestry bureau of that State has directed its attention chiefly to the education of the people in regard to forestry matters, so as to induce the individual landowners to cultivate and protect properly their own forests. In the fourth annual report of the bureau attention is called to the general need of information on the subject, and the demand is made that forest botany and forest zoology be taught in the public schools and that, as a first step in this direction, these studies be introduced into all the normal schools and the State University without delay.

Tree planting, it is also urged, should be taught in the schools to a certain extent, and this may be done in connection with the annual Arbor Day celebrations. The secretary thinks the actual planting should not be done by teachers or pupils having no knowledge or experience in the work, but that the school authorities should engage experienced tree-planters to do the work in the presence of the schools.

It is further urged that the State University at Columbus should organize forthwith a forestry department in connection with the agricultural college, for the

education of professional foresters, of whom there is great need, both for the education of the young and for work in practical forestry.

There should also be a forestal experiment station in connection with the university, supplemented by primary and secondary stations in various parts of the State. The bureau, in connection with its other work, is now engaged in efforts to establish voluntary forestal experiment stations, with fair prospects of success.

It is also a sign of progress in forestry matters that the governor of Pennsylvania, Hon. James A. Beaver, has accepted the presidency of the American Forestry Congress, and in his message to the Pennsylvania State legislature takes special pains to refer to the forestry work of the congress as well as of the special commission appointed by him to examine and consider the subject of forestry in Pennsylvania.

As further illustrating the progress of forestry work in the country, it is necessary to report the doings of forestry and horticultural societies in various other States.

The people of Maine were manifesting increasing interest in the protection and conservative use of our forest wealth by holding, during the last year, a forestry convention, at which a committee was appointed for the purpose of urging the President to use his influence with Congress for the purpose of securing the withdrawal of the public timber lands from sale or occupation, and also to secure, by means of the next census, more ample and satisfactory information in regard to the forest condition of the country. The State Grange of Maine has also taken similar action.

In Massachusetts the Society for the Promotion of Agriculture has from time to time, for many years, offered premiums for the planting and cultivation of forest trees. Last year the society made an award of premiums, amounting to several thousand dollars, for the best plantations, and at the same time offered additional premiums for future planting.

The Pennsylvania Forestry Association, distinguished for its enterprise and efficiency, has done much during the past year, by lectures and the issue of its organ, *Forest Leaves*, to create a proper interest in forestry matters throughout the State. It has exerted what influence it could to induce appropriate measures by Congress for the protection of the public timber lands of the nation. It has undertaken to accumulate a permanent fund by means of which to employ a general agent, and so increase its efficiency. It has also determined to publish *Forest Leaves* regularly every month instead of at irregular intervals.

In Texas and Kentucky State forestry associations have been formed during the last year.

In Ohio interest in forestry has been stimulated during the past year by the exhibition of forest products which was made in connection with the Centennial Exposition at Cincinnati.

A forestry convention was held early in the year at Grand Rapids, Mich. The Michigan State Board of Agriculture was by legislative act constituted a board of forestry, for the purpose of devising and proposing needful forestry legislation. The report of this meeting and of the commission has been mentioned before.

It deserves to be mentioned that during the year a vigorous endeavor has been made to secure such a change in our public land laws as would protect and preserve the public timber lands as a source of permanent use and revenue. This had its initiation with the American Forestry Congress, as I have outlined in my last re-

port. A bill for an act was presented to both Houses of the late United States Congress, the chief provisions of which were the suspension of the sale of timber lands pending a survey of the same, then the permanent reservation of such portions of them as might be deemed necessary for climatic and other reasons, the wood only being sold from time to time under a system of licenses, to be cut and removed under the supervision and direction of Government officers appointed for the purpose. Petitions in favor of the bill from various bodies and from influential persons in almost all parts of the country were presented to Congress, but without effect, and the work remains to be renewed at the assembling of another Congress.

One of the most important events of the year in relation to the forestry reform movement was the meeting in November of the American Forestry Congress and the Southern Forestry Congress simultaneously, at Atlanta, Ga. The two congresses were merged in one, henceforth to be the American Forestry Congress. Three days were occupied with the reading of papers and the discussion of forest topics. Committees were appointed for the purpose of securing appropriate legislation by the National Congress for the protection of the public forests, and by State legislatures for the promotion of the interests of forestry in the several States.

Lastly I should mention, as not the least—perhaps the most welcome—development of the year, the establishment of a journal in this country, which not only devotes a part of its space to the discussion of matters relating to the forest, but is bold enough to enter the name on its title.

Garden and Forest is a weekly journal of horticulture, landscape art, and forestry, published by Prof. C. S. Sargent, well known by his census work on the forest flora and forests of the United States. It has brought during the year a large amount of forestry reading of the first order; and while for reasons of finance it is still necessary to give to the discussion of matters relating to gardening and landscape architecture the lion's share, it is to be hoped that the readers of forest literature will so grow in numbers as to make this part of the paper more and more its prominent feature.

The little publication issued by the Pennsylvania Association, *Forest Leaves*, has also gone on in its modest way, reaching a class of readers and serving a purpose different from that of the more pretentious journal just mentioned. By the adoption of this publication as the organ of the American Forestry Congress, a means of communication will be established between the workers on the field of reform in forest economics.

The general and the scientific press have also brought forth considerable discussion on forestry matters during the year. The question of forest influences has been widely discussed, and especially the influence of forests on rain-fall.

FOREST INFLUENCES.

Since Government action with regard to forest preservation and reforestation is called for largely upon the claim that the forest cover has an influence upon climatic, soil, and water conditions, and thus making forest conservancy a matter of general and public interest, the discussion and settlement of questions relating to these influences should be among the first duties of this Division. Unfortunately,

the Division is not placed in such a position as to enable it to do more than compilatory work; the establishment of stations with the special object of ascertaining forest influences, which was recommended in my former reports, is still, for obvious reasons, in abeyance. A thorough discussion and critical review of the knowledge and observations on forest climatic influences so far obtained in other ways has been contemplated, but, as yet, has not been completed.

One of the most notable discussions on the subject of the influence which forests exert on rain-fall occurred during this year in the Philosophical Society of Washington, lasting through nearly three meetings. This was called forth by a paper of the writer analyzing the methods employed in the discussion of this question. This paper was written in answer to an article by Mr. H. Gannet, geographer of the United States Geological Survey, aiming to prove the absence of forest influence upon rain-fall, which had unfortunately found wide circulation in the daily and weekly press. I say unfortunately, because while on the face of it the conclusions reached seemed to stand upon incontrovertible facts, and therefore the general public would be led to believe that a definite settlement of the question had been arrived at on a scientific basis, it was clearly shown in the discussions referred to that the conclusions were by no means justifiable and the flaws in the method and reasoning were made apparent.

Since Mr. Gannet's paper is among the few which refer in their treatment of the question to conditions prevailing in our own country, and since the readers of this report will be interested in seeing both sides of the controversy, it is proper that I should mention his method of dealing with the question and the discussions somewhat *in extenso*.

In the first place, as regards the choice of localities which were to be compared in regard to the amounts of precipitation during different periods, the prairie region comprising Iowa, northern Missouri, southern Minnesota, Illinois, and part of Indiana seemed to offer a proper field because, as it is asserted, during the last thirty years this great area has been considerably reforested by natural growth. On the other hand, Ohio, originally heavily wooded, has, as is known, been quite considerably deforested, and thus promises to yield valuable data for comparison. A third area was chosen, comprising New England and parts of New York, which, originally densely wooded, then almost entirely deforested, is said now to be largely grown up to wood again.

The author then attempts to solve the question whether these asserted changes in the soil-cover have been accompanied by changes in the amount of precipitation.

The rain-fall observations of twenty-four stations in the prairie region, varying in duration from ten years to forty years, are, for each station, divided into two equal periods and the amounts thus obtained for each of the two periods are added, when it is assumed that the sum of precipitation in the second period should furnish a larger number if the rain-fall had increased. It was found, however, that the sums were as follows:

Sum of annual precipitation:	
First half	8,375
Second half	8,032
Difference	—343

That is to say, the second half of the period showed a decrease in rain-fall, namely, 1.6 inch per year; only six stations showing an increase—the others a decrease.

In Ohio, where, according to the popular theory, the rain-fall should have decreased, observations of twelve stations covering periods varying from ten to forty-six years, were similarly treated, with the following result:

Sum of annual precipitation:	
First half	5,911
Second half	5,880
Difference	−31

Five stations showed an increase, seven a decrease. The average decrease was 0.21 inch per year, or so little that it could hardly prove the unfavorable influence of deforestation.

For New England, it is assumed that the period of deforestation lasted until the year 1860, during which time a decrease of rain-fall should be expected; after this time, with the assumed reforestation, an increase should be noticeable. The same operation as applied before, at eighteen stations before 1860 and at fourteen stations after 1860, gives the following result:

Sum of annual precipitation:	
Before 1860:	
First half	8,467
Second half	9,046
Difference	+579
After 1860:	
First half	4,582
Second half	4,582
Difference	0

The first period shows, contrary to expectations, a considerable increase of rain-fall (2.9 inches per year), while the reforestation after the period shows no influence.

Lastly, the author subjects twenty-six stations of the region west of the Missouri, with observations varying from six to twenty-six years, to this scrutiny and finds:

Sum of annual precipitation:	
First half	4,408
Second half	4,468
Difference	+60

Sixteen stations show an increase of rain-fall, but the total increase is not more than 0.4 inch. (The author does not recognize that the stations of longest record show the greatest increase; taking those with records of twelve or more years alone, the increase would be over 2 inches per year.)

The conclusions reached by the author are worded as follows: In regard to the negative results in the prairie region, he says: "I should be very slow to argue from this a deleterious action flowing from the increase of forests, but it seems to militate very strongly against a favorable action upon rain-fall." On finding the decrease for the Ohio region but 0.21 inch per year he says: "It is of course unnecessary to add that this change is too small to have any meaning." In regard to the New England figures, "deforesting seems to be ac-

companied by a decided increase in rain-fall." The increase of rain-fall west of the Mississippi is also considered too insignificant. The author then sums up in the following very positive deductions: "With these results in view, it seems idle to discuss further the influence of forests upon rain-fall from the economic point of view, as it is evidently too slight to be of the least practical importance. Man has not yet invented a method of controlling rain-fall." And in another place: "We may therefore dismiss as baseless the popular idea of an increase in rain-fall either annual or during the growing season."

In the discussion of this paper, referred to above, it was shown that these conclusions could not be drawn with such positiveness, for the following reasons:

(1) The method employed is inadmissible because it uses incongruous data for comparison, the periods of observations drawn together being of very uneven duration and therefore in their two halves not representing periods of different forest condition.

Most stations are of recent origin and furnish therefore no data for the conditions of older times; by adding half their results to these actually referring to earlier conditions, the tendency would be to equalize the results.

(2) It was doubted that the reforestation of the prairies, on the whole, had taken place to such an extent as to appreciably change its forest area. For the Ohio region it was to be remarked that the main deforestation took place at the end of the preceding and beginning of this century, while most of the stations are only ten or twenty years old (only three are older), and therefore do not present data covering a time of appreciably greater forest area. It was also doubted whether the waste lands of New England covered with a sparse brush-wood could be considered as forest areas exerting an influence.

(3) The material used for the discussion, granting that it presented reliable data, which was doubted, was inadequate for the reasons adduced.

(4) It was shown that periodical variations exist in the amount of precipitation, which can be expressed by a wave-line or curve with recurring high and low levels. By cutting any one period in these in an arbitrary manner, any result may be obtained that seemed desirable. It was therefore advisable to compare only periods relating to the same historic times, and of sufficiently long duration to equalize the secular variations.

(5) Lastly, it was shown that whatever observations of rain-fall we have are absolutely unreliable and useless for the discussion of forest influences, since it is not the rain-fall but the catch of different rain-gauges which we compare, and the rain-gauges which are or have been in use are liable to errors of very considerable magnitude.

The concurrence of opinion then recurred to the position which had been taken by the writer at the outset, namely, that we had no data upon which to discuss the question with precision and on a mathematical basis.

In regard to the last two points, I deem it of interest to reproduce in abstract the papers of Mr. A. H. Hazen and Prof. Cleveland Abbe, of the Signal Service, which were read during these discussions.

Mr. Hazen referred to the secular variations which are known to exist in every series of annual precipitation, and which are of such

magnitude as to overshadow any influence like that of the forest. He also pointed out that deciduous forests, such as alone concern us in the regions under observation, can influence rain-fall only during the season of leaf; and if the other seasons are united with this the result will be masked as far as this influence is concerned.

We have several stations in the region referred to with a record of about forty-eight years. Taking the observations of these during May, June, July, August, and September, and summing up separately the precipitation during the first and during the second twenty-four years, we find as follows:

	Summer rain in inches.			
	St. Louis.	Madison.	Muscatine.	Marengo.
First twenty-four years	540	517	545	506
Second twenty-four years	453	451	471	449
Decrease second period	87	66	74	57

These results would lead us to conjecture a reducing influence of forests on rain-fall.

But it is found on projecting the curves of rain-fall observations that a minimum in the secular variation occurs about the year 1877 or within the last period of our observations, and this accounts for the smaller amounts or decrease in the last half of the period.

Besides, the writer argued from his own observations the reforestation claimed for the region in which the stations are situated has been so slight that it could not very well be considered as a factor of climatic influence. He argued further, from the observation that fogs linger much longer over a forest than over an adjoining field, that a greater humidity of atmosphere above the forest must be admitted, which tends to increase precipitation, and since the air is less desiccated over a forest than over an open field, rain-drops when formed in the upper strata are not dried up in their descent when reaching this air of greater humidity as they would be in the drier atmosphere above the field.

Professor Abbe showed that all observations hitherto made with rain-gauges at various heights above ground agreed in demonstrating a very decided diminution in the catch of the gauge, the diminution increasing with the height. The relation between the catch at any height and that of the normal gauge at the ground is, approximately:

$$\text{Deficit}=\frac{\text{Lower}-\text{Upper}}{\text{Lower}}=0.07\times\sqrt{\text{altitude of upper in feet}}$$

This deficit is due to the effect of wind in drifting the slowly falling particles of snow and fine rain out of, over, and away from the gauge. The numerical coefficient, 7 per cent., is an average for the winds, snows, and fine rains of Europe, and varies with the special character of every wind. The only practicable method of allowing for this effect, and one that really does give a sufficiently valuable correction to ordinary rain-gauge measures, consists in placing several gauges near each other and at different altitudes (h' and h'') and reading their indications at every storm (u' and u''), then by elimination deducing

the reduction (x) to normal gauge of the readings for that storm. The equations are:

$$\frac{u'}{\text{normal}}=1-x\sqrt{h'} \qquad \frac{u''}{\text{normal}}=1-x\sqrt{h''}$$

Whence

$$x=\frac{u'-u''}{u'\sqrt{h''}-u''\sqrt{h'}}$$

And

$$\text{Normal rain-fall}=\frac{u'}{1-x\sqrt{h'}}-\frac{u''}{1-x\sqrt{h''}}, \text{ etc.}$$

The author showed that the shielded gauges devised by Prof. Joseph Henry in 1856 and Prof. F. E. Nipher in 1876, and the protected gauges used by Börnstein, Wild, and Hellmann, to a very considerable extent overcame in a mechanical manner the injurious influences of eddies at the mouth of the gauge caused by the wind, but they do not give much satisfaction in the measurement of snow.

The differences exhibited by a number of gauges scattered over an area of two square miles, as for example in the experimental rain fields near Berlin and the gauges scattered over the District of Columbia, are not entirely due to local geographical distribution of rain-fall, but also to local peculiarities of the strength of the wind by reason of which the catch is affected as above.

The chronological irregularities in the record of a single gauge kept for a long time in one locality are very largely due to chronological irregularities in the wind attending the rain and in the character of the precipitation, namely, fine rain or snow. Thus questions of the gradual change in climate as shown by rain-fall can not be intelligently discussed until the records of the rain-gauges are corrected for the insidious and, relatively speaking, enormous errors introduced by the action of the wind at the mouth of the gauge.

The author stated that already in Bavaria and in India, during the past two years, the importance of this correction has been realized, and the proper method of computing it, as above suggested, by two gauges at different heights, has been introduced. He added that, in order to rescue from condemnation the records of long-standing gauges in this country, it would seem proper to establish near each one another gauge at much lower or higher altitude, in order, by the comparison of the two, to obtain an approximate correction of the past records. At the present time there are no records of rain-fall in this country adapted to give satisfactory answer to any question involving variations in amounts of only 5 or 10 per cent. of precipitation.

Since it will aid the student of these questions to have before him a brief review of the methods that have been employed in discussing the influence that forests have on climate, I reproduce here such parts of my paper above referred to as seem appropriate.

While we may discuss to a certain limit, separately, the influence of the forest on any one of the different factors which we comprise under the collective name of climate, upon rain-fall, for instance, it must be apparent that such an intimate relation exists between the different factors of climate that it is almost impossible, at least impracticable, to confine the discussion to one factor or set of factors

without reference to the others. From a practical stand-point the aggregate effect rather than that of its component parts is of significance, the total influence being that which is of practical value. What does it matter, for instance, whether it is by increased precipitation that the forest benefits the field or whether the same physiological effect is produced by greater frequency of rains, or by more seasonable rains, or by increased relative humidity in other ways, or by raising the water level and increasing or advantageously disposing of the available water supplies through favorable ground-water conditions or surface channels?

And when we come to discuss forest influences with a view to a national forest policy, the further mechanical influence which a forest cover exerts upon water supply and water distribution, upon soil conditions and health—influences very distinct from those on climatic conditions and often of greater importance—demands proper attention and investigation, and it will not do to divide and discourage the work of forest commissions and forestry associations, as has been done, because seemingly one of the influences upon which they base their activity remains unproven.

As is natural, the first suggestion that a relation between climate and forest area exists came from general observation.

Especially when history had reported fertile districts with favorable climate, surrounded by verdant groves, where now desert wastes, inhospitable climate, and treeless mountain sides are found, the conclusion lay near that there existed a relation between the forests on one hand and fertility and favorable climatic conditions on the other.

According to Humboldt (Kosmos, Vol. II, p. 322), the decrease of humidity and rain-fall was recognized as a consequence of forest destruction as early as the fifteenth century. Sully, in the sixteenth, and Colbert, in the seventeenth century, warned against forest devastation, and the examples adduced for the fact of its bad effects form a voluminous library. Among the eminent men who have used this method may be mentioned Du Monceau, Réaumur, Buffon, Humboldt, and Arndt.

This method of proving the proposition, which has been the most popular, and is still largely in vogue, may be called the historico-statistical. It can not be entirely dispensed with and its conclusions disregarded, but its results must be considered with great caution, for not only are the reports of the facts in many cases dubious, but the inferences are not always reasonable.

About the middle of this century, with the development of physical and especially meteorological science, a second method was applied. This method, which may be called the argumentative method, attempted, upon a theoretical basis, to discuss and reason out the assumed relation by employing the accumulated physical knowledge which, scanty at first, has lately, however, been considerably increased.

Among the prominent meteorologists who employed this method, the first was Becquerel. The result of this method has brought us considerably forward in the recognition of the direction in which an influence would be possible; and while it has not been able either to prove or disprove satisfactorily the existence of the same, nor to advance us in the knowledge of the degree and quality of the influence, if any, it has cleared the way for a more scientific consideration and investigation of the subject.

The theoretical positions and conclusions resulting from this method may be formulated in the following twelve theses:

(1) We must be clear as to what shall be considered as "forest." It is evident that, according to composition, height, and closeness of growth, and size and extent of the forest, etc., the conditions must vary considerably. The position towards prevailing winds, water surfaces, mountains, the altitude, distance from the sea, and other disturbing influences, and the seasons also must be taken into account.

(2) The inquiry must discern between mechanical and physical effects, climatic conditions of the atmosphere, and hydrologic and mechanical conditions of the soil. It must also discern between an inquiry on the one hand into the climatic conditions of the forest interior and the changes produced over the same area by deforestation, and on the other hand into the influence of a forest area on its surroundings.

(3) As regards the climatic conditions of the forest interior in comparison with the open plain, the following facts seem established: (*a*) The mean annual temperature and the temperature extremes or range of temperature of the forest air is lower; especially in summer the days are cooler, the nights warmer. (*b*) The relative but not the absolute humidity is greater. (*c*) Precipitation seems to be more frequent and greater in amount over forest areas.

(4) In order to effect any tangible influence a distribution of field and forest must exist which allows an exchange of climatic peculiarities, such exchange being possible only by diffusion vertically and by circulation of air currents, local currents, or general air movements horizontally.

(5) Local currents set up in the same manner as by large water surfaces, through the difference in the temperature of forest and field during clear sky and quiet air, bring in summer in the day-time cooler air from the forest to the lower strata of the field, and to the higher strata during the night warmer and moister air which tends to formation of dew and mist.

(6) General air currents may be influenced variously according to their quality and direction. A windward position of the forest is necessary to have its climatic peculiarities communicated to the field. The dry, warm currents of the summer seem to be best capable and likely to carry the influence.

(7) Active transpiration in summer must tend to increase humidity of the air above the forest, and air currents nearly saturated passing over it may be brought nearer to condensation while the open field tends the other way. The cooler air of the forest tends to condense any warm, moist currents passing over it. The cooler stems and branches in winter and the slower rise of temperature in the spring in the forest tends to condensation, while the mechanical retardation of air currents which have begun to deposit their moisture tends to increase the precipitation.

(8) The mechanical effect upon the horizontal movement of the air currents necessitates an upward movement, which has a cooling effect and consequently increases their relative humidity.

(9) The greater humidity above the forest tends to enlarge and multiply the rain-drops of a falling rain.

(10) Mountain forests in spring favor precipitation in their interior; in fall, when they are relatively warmer, the opposite tendency prevails. Mountain forests on the leeward side increase the tendency towards condensation of dry, warm, and of moist currents.

(11) The condensation and precipitation may take place above the forest and thus render the currents drier after passage, or else they may carry their increased stores of moisture to the field, the temperature and moist conditions of which will determine their utilization.

(12) The effect upon air currents in contact with the atmosphere above the forest reaches only the lower strata, while all the heavier rain-falls are precipitated from greater heights (1,500 to 2,500 meters).

A very able review of the theoretic considerations which bear upon the philosophy of the forest influences upon climate, lately published by Dr. Hornberger, summarizes as follows:

(1) Theoretically considered, a climatic influence of the forest upon its surroundings may quite reasonably be assumed, yet the same considerations which lead to this conclusion allow us also to prognosticate that this influence is not very significant (considerably less than is often believed).

(2) In regard to the quantity of this influence and the distance to which it extends we possess no positive data; those extant show at least the insignificance of this influence.

It is, however, undeniable that the data which the author recognizes as satisfactory to himself, upon which he draws his inferences, would prove him *a priori* biased in opposition to the accepted theory; and while he strives faithfully to explain the physical conditions, his inferences are certainly tinged by his bias.

The next step and method of demonstration employed was the mathematical one, using numerical data which had either accumulated independently of the question or were specially provided for the purpose.

We have here to distinguish two methods, a wholesale and a retail one, if I may so express it, or, more scientifically speaking, the one using large averages and comparing data from extensive areas, not specially supplied for the purpose, the other comparing directly data obtained in confined localities, by direct detail measurements within and without forest areas.

The latter method, which I call the retail one, is the one now largely adopted by German investigators.

The first attempt to obtain for the settlement of this question a series of exact methodical observations dates back to the year 1864, when Dr. Ebermayer, professor at the University of Munich, constructed the necessary apparatus, and, with the aid of the Bavarian Government and forest administration, established, in 1866, the first three double stations (a set of meteorological instruments being observed within a forest area and another set simultaneously in a field near by), with an extension in the following year to six stations. In 1869 Switzerland followed with three stations; in 1870 Italy established a station, and in 1874 to 1877 Prussia entered upon this field of work, having now sixteen stations in connection with the forest experiment stations; and to-day quite a number of such double stations are collecting data in all parts of the country.

A summary of the first results of the Bavarian stations was published in 1873, and at present monthly bulletins and an annual summary are published by the Prussian stations, the thirteenth annual being now due.

The object of these double stations, at which instruments are placed within the forest and in the open field, is to note—

(1) The temperature of the atmosphere within and without the forests.

(2) The temperature in the forest at 1.5^{m} above ground and in the tree-tops.

(3) The degree of humidity within and without the forests.

(4) Evaporation within and without.

(5) Quantity of precipitation reaching the ground.

(6) Temperature of soil at six different depths.

The points of observation at the Prussian stations are chosen 200^{m} distant from the edge of the forest both ways. An enormous amount of material has accumulated, but as yet has not been summarized or turned to account. It is difficult to see how anything else can be demonstrated by it than what is already known, namely, that the meteorological conditions within the forest are different from those prevailing without. Whether and how far this difference is communicated to the open field can certainly not be proved by the data obtained. By establishing points of observation in the field at varying distances it might have been possible to demonstrate the presence or absence of climatic interaction between forest and field.

In the wholesale methods, which use data obtained over large areas independently of the special object of this proposition, we may again discern two ways of manipulation. The one comparing the data found during various periods at the same stations and bringing them in relation with forest conditions existing at the various periods; the other comparing data obtained simultaneously from stations situated differently as regards forest conditions, but capable of being brought to a proper basis of comparison as regards other climatic influences.

Mr. Gannet's method belongs to the first class. I have spoken of it before, and shown that his arrangement of data—even if they were reliable—is inadequate and leads to no result.

A more advantageous application of this method has been attempted by Prof. Mark W. Harrington, and although he does not inquire into, or at least leaves doubtful, the question of the causation, his results seem to indicate an increase of rain-fall over the same area with which Mr. Gannet deals. His application of the wholesale method consists in comparing isohyetal lines constructed for two different periods, about thirty years apart. The main objection to the conclusiveness of this method is that in the present case it depended on too inaccurate data.

The second class of wholesale methods which compares simultaneous data of stations differently situated as regards forest conditions, has been lately employed by the eminent Russian climatologist, A. Woeikoff. He chooses his illustrations from the northern part of India where, as the author states, the temperature variations from south to north are exceedingly slight, being, between the nineteenth and thirty-first degrees of latitude, only 0.08 degree C. for each degree of latitude, and where the months of April to June represent the hot season and are very dry. Between the twenty-third and twenty-seventh degrees there exist treeless regions, especially the larger part of Bengal and the Northwest Provinces, while the provinces of Assam, Sylhet, and Cochar, etc., are densely wooded.

He shows by tables of meteorological data that in the wooded regions of Assam, even at a considerable distance from the sea—

(1) The hot season from April to June, which prevails on the open Gangetic plain, is absent.

(2) The mean temperature of the months of April to June (the hot season) is 4 to 6 degrees lower than in the treeless region at equal

distance from the sea (a difference which at such a latitude and such nearness of stations—550 kilometers in the plain—and the absence of mountain influences is nowhere else observed).

(3) The temperature maxima differ even more than the means, because in the forested area not greater than those of Southern or Middle Russia, while in the treeless part, even near the sea, temperatures of 40 and 45 degrees C. are frequent.

(4) The humidity of the atmosphere is great in the densely wooded part of Assam even in April to June, namely, 40 and more per cent. above the mean relative humidity of treeless stations equally distant from the sea.

(5) This may explain the earlier beginning and the regular increase of precipitations over the wooded areas, while in the west a sudden increase takes place.

(6) The relative humidity is also greater in the forested area during the dry months, especially December, although no precipitation may fall, the relative humidity being 82 per cent. as against 60 per cent. in the open country, at two stations equidistant from the sea.

The author admits that whenever the general climatic conditions of a subtropic country are opposed to precipitation, even over larger forest areas rain will not fall; for instance, when the wind is a constantly descending one or comes from cooler, drier regions, like the northeast winds in Assam from November to February.

His tables show the temperature, moisture conditions, and precipitation at ten stations within the twenty-second and twenty-seventh degrees of latitude, and the extreme differences of annual precipitation noted are 687^{mm} and $2,975^{mm}$, or a variation of $2,288^{mm}$; and if we take two stations equally distant from the sea for comparison, Patna and Goalpara, the difference is $1,370^{mm}$, a significant figure when we consider that the two stations are only 340 miles from each other.

Thus it would appear that, at least for subtropic regions, the effect of forest cover in reducing temperature and increasing precipitations may be accepted.

Woeikoff further investigates whether the influence of the forests upon climatic conditions of their surroundings may also be proved for latitudes of 38 to 52 degrees north—all the west European continent—and he proceeds as follows:

Taking the temperature of July as that of the warmest month, and assuming that on the whole the temperature at the Atlantic coast is lower and rises toward the interior of the continent, he compares the temperature of a number of places situated near the fiftieth degree, the observations being all taken outside of the forest. To bring them upon a uniform basis for comparison, he reduces the observed quantities by assuming the increase of temperature toward the south at 0.5 degree C. per degree of latitude, and for every 100^{m} of altitude he assumes a temperature difference of 0.7 degree; he does not, however, reduce to sea-level but to 200^{m} altitude, in order to avoid many reductions and so to lessen the possibility of error. Thus he obtains mean July temperatures for his line of stations reduced to fifty degrees north latitude and 200^{m} altitude.

He observes in this series a rapid rise of temperature from the Main River, then a considerable reduction in the eastern and western Bohemian stations, which is credited to large forest areas there prevailing, while in the Bohemian basin the temperature is higher, as it is also in Silesia, and again much lower in the well-wooded Carpathian Mountains of Hungary; the influence of these large wooded areas is

still noticeable in East Galicia as far as Kiew, where the neighborhood of forest and morasses works in the same way; while in the steppes the highest temperature is reached.

In the same manner a series of stations lying on or near the forty-sixth degree are treated, reducing their July temperatures to the theoretical temperatures for the forty-sixth degree and 200^{m} altitude; and another series of stations is worked out for the forty-fourth degree in Croatia, Bosnia, Herzegovina, and Dalmatia; and here the heavily-wooded Bosnia is found from twenty-five to forty-five degrees cooler.

The results of these comparisons lead the author to conclude that in the western part of the continent large forest areas influence the temperature of neighboring localities and interrupt the normal increase of temperature which should occur in going from the Atlantic Ocean into the interior of the continent, to such an extent that even regions far in the interior have a cooler summer than those nearer the sea.

He concludes, further, not only that there exists a climatic influence of the forest, but that it exerts itself over considerable distances according to composition, size, and position of the forest area; that, therefore, *forest planting or deforestation offer a means of changing considerably the climate.* And he adds:

> Some people hold that since the forest increases precipitation it is only necessary that forests be planted to wipe out the deserts. But such an extreme position is not tenable. Although the forest economizes the precipitation that has fallen, storing it for a long time and increasing the quantity to a certain degree, yet many parts of the earth are too arid to bear forests (?), for forests need much water. On the other hand, thinly-stocked forests and those composed of trees with a foliage covered with a wax-like substance which decreases transpiration, while better capable of sustaining themselves in dry climates than denser forests and those composed of trees with more active transpiration, yet do not mitigate the heat and moisture in the same degree.

One may say in criticism of this method, that the factors of reduction are somewhat arbitrary and may not be correct, and that the divergence of the reduced temperatures may not be caused by the forest; and further that the difference is established (if at all) only for the summer temperatures, but not for the yearly or daily variations, therefore the data are insufficient to prove the propositions in their generality.

Mr. Henry F. Blanford, meteorological reporter to the government of India, also asserts that the difference of rain-fall in the two localities compared by Woeikoff may be attributed to other physical conditions. He thinks that a satisfactory solution of the question must await the production of a series of rain-fall records from a single region, which is forested for a time, and then deforested, or *vice versa*, and he contributes such an observation from the Central Provinces of India south of the Satpura Range, where five-sixths of an area of 61,000 square miles had been greatly deforested.

The records from the years 1865 to 1875, made during the time of deforestation, are compared with those of the following period, when, through government interference, systematic reforestation began. During the second period the rain-fall has progressively increased, until the mean for fourteen stations appears to be 20 per cent. more than it was for the first ten years.

Dr. Brandis, for a long time forest inspector-general of British India, also cites another example of the same kind from the Central Provinces north of the Nerbudda River, where the increase of mean

annual rain-fall has shown a gradual increase of 6.2 inches or 12½ per cent. in ten years, after an area of 600,000 acres of woodland had been protected against fires and had grown up densely. He says:

The relations of forests and rain-fall in India are manifold and mutual. When thirty years ago forest management was systematically organized, it was mainly with the object of securing continuity of wood and other forest products, and in mountainous districts to secure the loose soil from washing off, to prevent the filling of the rivers with sand, and to check the floods. Later on, experience taught that especially in regions with an arid climate, and even moister regions during unusually dry years, the grass grew more luxuriantly in the woods and gave more plentiful pasturage than on unwooded lands.

But it had not been anticipated that forest preservation and reforestation would in any degree affect the annual precipitation. Yet during the last few years it has become apparent that in some sections an increase of the annual rain-fall has gone hand in hand with forest protection.

In that part of the Central Provinces which lies between the Nerbudda River and the plains of Nagour and Raipur, a total area of nearly 600,000 acres of forest has been protected for a series of years against the annual fires of the hot season.

The records of seven stations for eighteen to twenty years allow the following tabulation of mean annual precipitation:

Stations.	Precipitation for different periods.		Precipitation for 1876–1885.	Difference.
	Period.	Precipitation.		
Badnur	1867—1875	39.83	47.83	+ 8.00
Chindwara	1865—1875	41.43	48.48	+ 7.05
Seoni	1865—1875	52.07	54.76	+ 2.69
Mandia	1867—1875	53.58	56.32	+ 2.74
Burha	1867—1875	64.51	71.65	+ 7.14
Bilaspur	1865—1875	41.85	54.81	+12.96
Raipur	1866—1875	51.59	54.47	+ 2.82
Annual mean		49.27	35.47	+ 6.20

Blanford, who has recorded these observations in the above manner, adds that these results, of themselves, are not proof absolute for the influence of forest preservation, since possibly the earlier observations were less reliable than the later, but that these observations may be considered as addenda to the accumulating signs of the existence of such influence on rain-fall.

But even this method, which would class with my retail methods, although seemingly simple, before it can be admitted as conclusive, must, as the writer says, be guarded by those special precautions which are demanded by strict scientific inquiry.*

*The above figures were hailed with satisfaction by those who are bound to prove by statistics the forest influence on rain-fall.

Unfortunately, as this report goes to press, their value is entirely vitiated by the following statements made in the *Indian Forester*, January, 1889, which again admonishes us to be careful in placing too much weight on statistics:

"Mr. Blanford, in order to assure himself of the value of the rain-fall returns he employed in the discussion of the Central Provinces, wrote to the chief commissioner on the subject, to which the reply was received that 'the chief commissioner fears that these records of rain-fall previous to 1883 can not be accepted as altogether reliable.' The commissioner explains the reasons why the records appear unreliable, and adds: 'Hence one result of the unsystematic registration of the rain-fall in the Central Provinces is to postpone the decision of the influence of forests on rain-fall in that area for another twenty years. It is only one of the many cases of the worthlessness of unsystematic observations.'"

It is of interest also to note the following from the same source:

In the following extract from the same report Mr. Eliot refers to the observations recently undertaken in the forests of the Saharunpoor district. For the reader un-

Lastly, I wish to call attention to the latest, most valuable scientific work which has been done to decide the important but difficult question of the influence of forests on precipitation. I refer to the work of Dr. F. J. Studniçka, professor of mathematics at the University of Prague, published under the title "Basis for a Hyetography of Bohemia," in which the results of many years of observation at seven hundred ombrometric stations are embodied, critically sifted and scientifically considered.

The author employs a wholesale method which is quite novel, complying with Woeikoff's idea that it is necessary to reduce the observed data upon a common basis for comparison.

To understand the significance of these observations an inspection of the map of Bohemia will be desirable, which shows it to be a basin surrounded on all sides by high mountains.

The work of ombrometric observations, although begun in Bohemia during the last century, was newly organized in 1879 or 1880, when a systematic net of ombrometric stations was instituted, and in 1885 and 1886 it was extended to over seven hundred stations, for the purpose of obtaining accurate data of the quantity and distribution of precipitation over the kingdom. Uniform ombrometers were used and very carefully placed. As at present organized, there is one station for every 75 square kilometers (about 30 square miles). No other country, I believe, can boast such a service. Although the time of observation at most stations has been short, and the averages would have been more accurately represented by an extension of observations for ten to twelve years, yet the last four years of observation, for which all stations furnish data, according to the author, represent two extreme and two average years, and are therefore quite useful.

The very large mass of material permitted a sifting out of doubtful observations without impairing the number of available ones for the construction of a rain-map of Bohemia, showing by isohyetal lines seven rain-belts or zones; the zones are arranged so that the lowest shows less than 500^{mm} rain-fall, the three following differ by 100^{mm} each, the fifth and sixth by 200^{mm}, and the seventh by 300^{mm}; the last showing, therefore, a rain-fall of $1,200^{mm}$ to $1,500^{mm}$.

The central basin divides itself into two halves by a line from north to south, running somewhat east of the middle Moldau, crossing the Elbe near the mouth of the Iser, and following the latter river; the western half showing the smaller amount of precipita-

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acquainted with the Western Himalayas it is necessary to explain that a *rao* is a water-course issuing from the hills, and having, generally, a broad, shallow bed, which consists mainly of bowlders and shingle, and is therefore quite dry or almost dry, except after a continuous heavy shower. Mr. Eliot has not mentioned that in each *rao* levels are accurately taken every year along one and the same line, in order to note the changes that may occur in the section of the *rao* in consequence of the fire conservancy of the entire basin above.

"A different method has been introduced in the Saharunpoor forest division. Twelve representative *raos*, between the Ganges and Jumna Rivers, have been selected for purposes of observation by the inspector-general of forests and conservator of the school circle, and in each forest chowki a rain-gauge is suitably placed. Five of them are located in the forest of Sakrauda, which is neither closed to grazing nor protected from fire. The rain-fall measurements will be made by the forest guards, and the returns submitted to the meteorological department for critical examination. These observations will probably give a valuable series of data for testing the effect of different forest conditions in modifying the amount of rain-fall, and hence also probably throw some light on the general question of the influence of afforestation on rain-fall."

tion, namely, 500 to 600^{mm}; the eastern with 600 to 700^{mm}, continuing in a small belt along the foot of the Erzgebirge and the Boehmerwald encircling the first zone.

The other isohyetal lines do not embrace continuous areas, but follow in small belts the trend of the mountains. The largest amounts of precipitation are found in belts or islands in the higher altitudes of the mountains which surround this great basin. The continuity of the zones is much interrupted, so that it would be difficult to describe them without a map.

The maximum of rain-fall with over 1,200^{mm} is observed in the south near the sources of the Moldau and Motawa, in the north near the sources of the Elbe, Iser, and Aupa on the range of the Schneekoppe. In regard to the distribution through the months, the experience has been confirmed that with increasing absolute height the winter precipitation increases in greater proportion than the summer precipitation, while those of spring and autumn are nearly equal.

Sufficient material was on hand from which to calculate the influence of altitude on the increase of precipitations, although for altitudes above 500^{m} the material is not considered sufficiently reliable. Yet the general law is well shown that with the altitude the quantities of precipitation increase in a retarded progression. This progression is calculated by forming altitude zones from 100 to 100^{m}, grouping the stations in each, calculating the mean elevation and also the mean annual precipitation as observed for each class; then by dividing the difference of precipitation in the neighboring two zones by the difference of altitude the amount of precipitation which corresponds to each 1^{m} elevation within that class is found. With this figure the average amount of rain-fall which theoretically belongs to each station according to its absolute elevation can be approximated by adding to or subtracting from the mean precipitations of the class as many times this amount as the actual altitude differs from the mean.

An example will make this clear:

Tetschen, for instance, is situated 150^{m} above sea-level. According to the table the average elevation of thirteen stations of the lowest zone, to which Tetschen belongs, is 182^{m}, with an average precipitation of 506^{mm}. Now Tetschen has an elevation 32^{m} lower than the average; its normal rain-fall should therefore be $32\times0.79=25.4^{mm}$ less than the mean of the class; hence, theoretically, according to its altitude, the quantity of rain-fall for Tetschen should be $506 - 25.4=480^{mm}$; that is, 248^{mm} less than that actually found in an 8 years' average.

By using the figures for the two extreme zones and dividing by 100, the mean increase of precipitation for every 100^{m} elevation is found to be 69^{mm}.

And now comes the application of this method to our proposition. The author argues that if the actually observed rain-fall differs considerably from the theoretically determined, this is an indication that special agencies are at work.

He finds now that of the one hundred and eighty-six stations which he subjects to scrutiny (these offering the longest and most trustworthy observation), forty-eight show a considerable difference between the observed and the theoretically expected rain-fall, and he finds also that these stations are situated in the most densely wooded portions of the kingdom.

The increased rain-fall on the forty-eight stations is so considerable that a sufficient quantity may without losing significance be ascribed to other local causes, as for instance, height and form of a mountain range in front or back, etc. Besides, the greater amounts of rain-fall at these stations have been used in calculating the averages for the altitude zones, magnifying therefore these averages so that the actual difference between the calculated quantity and the actually observed one appears really smaller than if the quantities from deforested and forest areas are compared.

Expressed in percentages of the height of precipitation, an increased rain-fall is shown for several localities in very large quantities, which will allow considerable reductions for other influences without losing their significance for the main proposition.

Especially important appears the fact relating to two stations near the rain minimum, which also shows this influence of the forest.

Lastly, as a matter of interest I may state that the water balance is drawn for the whole kingdom, which is of special value because the political boundaries coincide with those of the Upper Elbe watershed; therefore it is easy to determine how much of the yearly rainfall is removed by the natural water-courses. According to the calculations made for the various zones by addition, the total precipitation upon the area of 51,955.98 square kilometers (about 20,000,000 square miles) of the kingdom is found to be 35,398,670 cubic meters, of which the Elbe carries about one-fourth or 10 cubic kilometers to the sea. This figure represents a mean rain-fall for the whole country of 681^{mm} while the mean of observation is 693^{mm}.

From the recital of these methods, their results and the difficulties attending their application, it would appear that no one of the methods employed will alone be sufficient to investigate such a complicated relation in its generality as that which they try to establish or refute. All of them, modified and provided with such safeguards as will exclude the many disturbing influences, will have to work together towards a solution of the question, which is by no means settled as yet.

It has been safely established by experiment that all soil covers, whether they consist of grass, agricultural crops, shrubs, or trees, derive very considerable quantities of water from the soil which they transfer to the atmosphere. The influence of a forest may therefore not be greater than that of any other vegetable cover—as long as the soil remains so covered—in increasing the humidity of the atmosphere, especially since the amounts of evaporated water from various forms of vegetation do not differ appreciably enough in quantity. An influence on the amount of rain-fall, which is very different from an influence on the distribution of rain-fall, may possibly be observed where deforestation takes place over wide areas and where the soil is not again clothed with vegetation, as has undoubtedly been the case in the arid regions and as may happen on mountain sides, where the earth is carried off by the waters after deforestation.

In regard to the influence upon amounts of precipitation, the question can probably be only between bare soil and soil covered with vegetation, but not between forests and other forms of vegetation.

I ought to make mention here of a most interesting account of the influence of deforestation in Australia, which has perhaps some bearing on our own conditions in the western treeless regions, and which tends to show that a forest may, under given conditions, exert very undesirable influences. It is published by R. von Lendenfeld. The

writer premises "that the influence of forests in Australia differs from that in Europe." The opinion of the inhabitants is divided upon this point; the most general opinion is that with deforestation the climate becomes drier, while the squatters and sheep owners deny any influence.

Australia is very dry, and with the exception of the northern part, which is subject to tropical rains, and the eastern and southeastern mountainous shore, the rainfall is exceedingly small. Even near the coast of New South Wales and Victoria the average annual precipitation is only 8 inches.

All plants possess special apparatus for increasing the water supply from below, deep-root systems, and for diminishing transpiration.

Almost all trees and shrubs of the interior of Australia produce large amounts of etheric oil. This cools the leaves by its evaporation, and spreads itself in gaseous form over the forest. The air thus filled with ether is less pervious to heat rays than the pure atmosphere, and thus the tree protects itself against heat and rapid transpiration. The eucalyptus trees turn their leaves obliquely to the sun, in order to reduce the amount of insolation.

Besides these protected plants, there are many herbs and grasses which lack any protection, but, being prolific seeders, after every rain their seed lying in the soil germinates and quickly covers the bare ground with a fresh green, but as soon as the water of the superficial strata is consumed they die.

The trees, sending their roots into the depths, consume all the water of the lower strata, so that no grass is seen in the forest; the soil is smooth and hard like a stone.

When it rains in such forests the greater amount of the water flows off over the hard, smooth soil without being able to penetrate the closely-packed, impervious soil.

Therefore here the forest does not prevent the rapid flow of the water, and does not increase the humidity of soil air.

After deforestation the grasses spring up, utilizing the ground water, which now, by capillary attraction, can reach them from below. This vegetation makes the soil porous, and the flow of water after rain is impeded; and since thus the water is retained and evaporated gradually, the humidity of the atmosphere is increased.

We therefore conclude that in warm and dry regions, like the interior of Australia, deforestation brings increase and not decrease of humidity and precipitation.

One of the most important influences claimed for the forest cover is that upon the water conditions and drainage of the soil. In this respect the year has brought very valuable results of experiments by Dr. E. Wollny and E. Ebermayer, who independently determined the influence of vegetable covers of the soil upon temperature and water conditions, and have with these settled pretty thoroughly the question of these influences. I regret that lack of space forbids a recital of these experiments and results.

TECHNOLOGICAL INVESTIGATIONS.

The two main lines of independent investigation in which the Division has been engaged during the year have been a continuation in the studies of the life history of our important conifers, so that now monographs on the more important Eastern conifers are ready awaiting publication, and secondly an investigation into their technological characters and qualities and the conditions under which these qualities are attained; somewhat on the same plan which was pursued by the eminent German forest botanists, Dr. R. Hartig and Dr. O. Noerdlinger in regard to the German timber trees.

This investigation had been planned late in the year 1887. Through the courtesy of Prof. V. M. Spalding several students at the botanical laboratory of Michigan University were engaged in preliminary work, studying microscopically the structure of various pines under the direction of Professor Spalding. In the course of the work, how-

ever, it was found that the dimensions of the undertaking were such as to require the close and constant attention of one man exclusively, such as Professor Spalding felt unable to give.

In consequence, early in the year 1888, Mr. Filbert Roth, curator of the museum of the Michigan University, was engaged to conduct these investigations in timber physics.

As I have explained in my report for 1887, while forest biology contemplates the forest and its components in their *living conditions*, I have grouped under the name of "timber physics" the results of all investigations into the character of the *dead material*. It is the analysis of our crop which will lead us to understand better the conditions under which we may grow it, and therefore these investigations are of as much practical value to the forest planter as those into the life history of our trees.

It would be considered folly for an agriculturist to grow a crop, which though capable of existing in the climate in which he operates, does not produce the fruit for which the crop is grown or the qualities for which it is prized. Still more so is it necessary for the forester to know what are the qualities for which a special timber is prized and under what conditions it can be expected to produce those qualities. To determine these questions is the object of these investigations.

I have divided the investigations in timber physics into the following separate branches:

The *anatomy of woods* considers the interior structure of the wood material, the arrangement of the various cell elements, fibers, canals, etc., which make up the body of the timber.

The structure of the timber stands in relation to its quality as cause and effect, or premise and sequence. Although there can be no doubt in regard to the existence of this relation, there is but little known of the degrees of qualities as dependent upon the modifications in the arrangement of the cell elements in the wood structure; the differences of quality of the different timbers are not, either, known positively; what we claim to know in this respect is assertion, rather, and supposition, not resting on exact experiments and scientific investigation.

Under this head it is necessary to study under the microscope not only the elements that form the wood, and the relative amounts of each of them in given areas, and their position, but also the gross anatomy as represented in the growth of the annual ring, the size, and rapidity of development, and its appearance upon the transverse section and through the length of the tree.

The *chemical physiology* of woods will teach us the dependence of our forest trees upon the mineral constituents of our soils; also the derivatives which we may extract from them, the amount of charcoal which ought to be obtainable, and its quality, etc., and many other matters of practical importance rely on this knowledge. This part of the investigations is for the present neglected, as also investigations into the diseases and faults of timber. Only as far as the knowledge of the components of the wood, especially its water contents, affects the technical qualities and uses of timber our investigation will touch this chapter of timber physics.

The most attention is given to the determination of the *physical properties* of the woods, and hand in hand with this an investigation into the influences which determine such properties.

It is apparent that, in order to carry out such investigations, the

selection of test pieces is of the greatest importance, and must be done with extraordinary care. To obtain such samples has been found quite difficult so far, partly for lack of proper persons to prepare them, partly for lack of funds to pay for the service properly.

Dr. Charles Mohr, the well-known botanist of Mobile, kindly supplied samples from the Southern pineries, and Mr. N. B. Pierce, of Ludington, Mich., a gentleman well versed in wood-craft, from the Northern pines.

The following instructions for taking test pieces accompanied the schedules for noting the data in reference to each test tree:

Instructions for taking samples of wood for technical investigations, and for notes concerning them.

(1) METHOD OF TAKING SAMPLES.

(*a*) Choose average representative trees; do not look for the largest or best nor the smallest or worst. Old trees are preferable.

When the tree is selected, mark with the ax the north and south sides. Before cutting off the bottom log, mark the north and south sides on the second cut, and so forth.

(*b*) At or near the butt-end of each log cut off a clear section 4 inches thick (rather less than more). Before cutting off the section indicate *on bottom of section*, with a thick pencil line, the *north* and *south* direction, writing the letter N on the north side and the letter S on the south side, both large and distinct.

Note on each section, as cut off, the *number of tree* corresponding to schedule with Roman numbers, and the *number of section*, beginning with number 1 at the base, with Arabic numbers. If the writing prove unsatisfactory, tack on a card with numbers in addition. This is to aid, not to replace, the marks on the wood.

If the section is heavier than 4 pounds (weight allowed in the mails), split some wood on each side of the N and S line, leaving a strip of at least 4 inches in width. If this is still too heavy, cut the piece in two through the center. If these pieces are still too heavy, cut them again in two halves between center and periphery. Split only if necessary, and never fail to write numbers and respective letter on every piece before splitting it off.

Weigh each piece and record weight in note-book. Measure carefully the distance from the ground to the first, second, etc., disk, and note them down at once.

(*c*) *Wrap* each piece separately in two separate wrappers of thin paper and one of thick oil paper. Let the paper be amply large, and well tied on with strong twine, so that no part can become in the least exposed.

(*d*) From one of the *large limbs* cut off disks like those of the trunk, one about 2 feet from stem and two more about 5 and 10 feet respectively from the first. Mark them with Roman number of tree, and Arabic numbers beginning with 1 for the piece nearest the stem. Besides the numbers, draw a line on the disk from the upper side of the limb to the lower side, and indicate the top side with a large T, the bottom with B; also note its position on trees as to exposure.

(*e*) From the base of the second log, or near it, cut off a 6-foot piece; let it be as free from knots as possible, and mark it in the same way as the sections. Cut another 6-foot piece from the base of one of the top logs; this piece also as clear as possible and at least 6 inches through. These pieces, while fresh, place in water and let them remain one week, then paint them at once at both ends, and stack them until called for.

(2) HOW TO DESCRIBE.

For each tree use separate sheet.

Write your name and full post-office address on back of each sheet.

Under *locality* note the place where the tree came from.

Under *description* give a general description of the locality; answers to questions like the following: Is the country level? If so, is it a low plain? High table land? Is it hilly, mountainous? In what direction do the mountains run? Is the country mostly wooded or cultivated land? Are the woods in large bodies? Are they deciduous or evergreen trees or are they mixed? Are the woods cleaned out (free from dead wood or under-brush)? Are any trees planted? If so, what kinds?

Under *site* is described the special situation of the tree. This comprises *geological formation*.

Lay of land.—State here whether the place where the tree stood is level, in a valley or on a slope (steep or gentle); mention angle of inclination if you can. State which way it slopes—to the north, south, etc. Is the place near the foot or near the top of the slope?

Soil.—State what color of soil, whether rich, middling, or poor. Is it clay, sandy loam, sand gravel, coarse or fine, and what kind of subsoil is there. How deep is the soil to the subsoil?

Moisture.—State if the place is swampy, wet, moist, dry; if near any water-course, a creek, or spring, and if ever overflowed.

Surface cover.—State if there is any grass or weeds on the ground. Is it mossy or bare? Is there any leaf-mold; if so, how deep? Is there any shrubbery? If so, name the principal kinds if you can.

Position and character of tree.—State whether the tree stood in a forest, in an open field, at the roadside. Has the ground been cultivated? If so, has the timber been planted; how long ago; how was it planted? Is the piece of woods large, dense, and what are the principal kinds of trees?

Here answer also the following: Is the tree large, average, or small compared with others of the same species? Was the crown large or small? Did it stand alone, in a cluster of the same kind of trees? How near to any tree? Was it higher than surrounding trees? Was it planted? If so, how? How was it cut?

In description, under *Position of test pieces* give distance of the base of each from the ground.

Under *Position of limb* state height from the ground on tree, and north or east, etc., side.

Remarks.—Here state anything which has not been stated and which may add to a full understanding of the conditions.

Tell of difficulties in finding, in cutting, in shipping or moving the wood; whether many trees are diseased, or other wise bad, and prevented your finding a suitable one.

Tell any peculiarities of the forest, as whether it is used as pasture; whether the dead wood is cleaned out; whether there is any systematic management of the forest, etc.

The timbers thus far brought under investigation by Mr. Roth have been, of Northern pines, *Pinus Strobus*, and partially, at least, *Pinus resinosa;* of Southern pines, *Pinus Cubensis*, *mitis*, *Tæda*, *glabra*, and also *Taxodium distichum*. The test pieces of *Pinus palustris* were unfortunately received before proper arrangements had been made to use them. Some interesting and some striking results, needing, however, further verification before generalization may be admissible and their value for the practice be recognized, have been already recorded, of which it may be proper to give a short résumé.*

It will be understood that the results and conclusions here presented from the work of Mr. Roth are of a preliminary nature, serving only to show the nature and progress of these investigations so far.

(*a*) *Density* or specific gravity; that is, quantity of ligneous substance in a given volume (usually the proportion contained in 100 cubic centimeters is stated).

The density in the wood of *Pinus Strobus* showed a rapid decrease from the base (41.4 grams) to a distance of about 19 feet from the ground (36 grams); from there to about 100 feet from the ground the decrease in density is more gradual.

The wood on the north side was invariably denser than that on the south side. In the case of *P. resinosa* the values were 70 near the base, decreasing to 60 and then increasing again to 72. In *Pinus mitis* and *Tæda* the same rapid decrease in density is observed near the base, in general, yet in more irregular stages than is exhibited by *Pinus Strobus*. The same irregularity is observed in these two southern

*As it is easier to make computations by the use of the metric system of measurement, this system has been employed in these investigations, and since no absolute but only relative values have so far been established, a translation of the results into English measure seemed to be uncalled for.

pines with regard to the relation of north and south side, sometimes the one and sometimes the other being the denser.

In *Pinus Cubensis* and *glabra* the decrease of density near the base is not nearly so rapid as in the other pines named, and while the minor irregularities in density observed in *Pinus Tæda* and *mitis* are found throughout the length of the tree the fluctuations are not nearly as great.

In *Taxodium* the relations of the different sections of the tree with regard to density differ very much from those observed in the pines. The density near the base showing 38 grams, it rises to 45 grams at about one-third of its height, then decreases again towards the top, where it was found to be 37 grams.

The density of the dry wood ranged as follows:

Pinus Strobus	41–32
Pinus resinosa	72–60
Pinus mitis	76–45
Pinus Tæda	61–40
Pinus Cubensis	59–40
Pinus glabra	54–40
Taxodium distichum	45–36

Shrinkage, that is the amount of volume lost by drying fresh wood at 100° C.

The shrinkage is very nearly proportional to the amount of organic substance or the density of dry wood, since it is due, as was found, to a loss of water not from the cell-lumen but from the cell-wall.

Pinus Strobus excelled in the regularity with which the capacity for shrinkage varies through the length of the tree. Beginning with 6 per cent. at the base, it rises to a maximum of 9 per cent. and then gradually falls again to 6 per cent. In *Pinus resinosa* the shrinkage proved very considerable, amounting to from 25 to 27 per cent. in the sap-wood and 16 to 19 per cent. in the heart-wood.

In the southern pines no such regularity as in the northern is observed, the values, if expressed graphically on the sides of a straight middle line, representing oscillating lines.

In *Taxodium* the curve of shrinkage is somewhat parallel to that of its density. It begins with 9 per cent., rising to 13 per cent. at about one-half of its height, and decreases again to 8 per cent. near the top.

The range of shrinkage percentages was as follows:

	Per cent.
Pinus Strobus	9–6
Pinus resinosa	27–16
Pinus mitis	20–12
Pinus Tæda	10–6
Pinus Cubensis	13–10
Pinus glabra	12–6
Taxodium distichum	13–8

The *amount of water* in the fresh wood of *Pinus Strobus* at the base was about 46 per cent., becoming smaller as we ascend the tree, until at about one-third of its height it has decreased to 40 per cent.; then it increases again to 48 per cent. at the top. It was also found that the same relation between north and south side of the tree exists as observed in regard to other properties; the north side showed a greater amount of water than the south side. *Pinus resinosa* ranged from 19 per cent. at the base to 39 per cent. in the last section.

In the southern pines the curve showing variations in the amounts of water contained in the wood begins with a minimum value near the base, increasing more or less gradually and reaching a maximum value near the top.

In *Pinus mitis* and *Tæda* there is again no constancy in the relations of north and south side, sometimes the one sometimes the other having the greater value.

In *Taxodium* the amount of water varies similarly to the density. Beginning with 53 per cent. at the base, it rises to 57 per cent. at mid-height, and falls again to 53 per cent. at the top.

The range of values was as follows:

	Per cent.
Pinus Strobus	46–40
Pinus resinosa	39–19
Taxodium distichum	57–53

In regard to the amount of *organic matter* or dry substance contained in 100 cubic centimeters of fresh wood, the following results were obtained: *Pinus Strobus*

showed the largest amount (38 grams) at the base, falling very rapidly, so that the second section showed only 32 grams, then falling more slowly until a minimum value was reached near the top (30 grams). The north side excelled in the relative abundance of organic matter.

Pinus resinosa showed values of 43 grams at the base, decreasing to 33 grams in the third section.

In the southern pines the values were considerably larger, ranging in—

Pinus mitis, between 64 and 45 grams.
Pinus Tæda, between 54 and 40 grams.
Pinus Cubensis, between 52 and 41 grams.
Pinus glabra, between 48 and 38 grams.

The same irregularity and inconstancy in conditions of the north and south sides as were observed with regard to other properties prevailed also in regard to the distribution of organic substance.

The rapid decrease in values near the base, so conspicuous in *Pinus Strobus*, is also noticed in *Pinus Tæda* and *mitis*, but is hardly perceptible in the case of *Pinus Cubensis* and *glabra*.

Taxodium showed a curve similar to that which represents the densities, commencing with 34 grams near the base, increasing to 40 grams at three-eighths of its height, then declining to 34 grams near the apex.

The *air-space* contained in 100 cubic centimeters of fresh wood after the water was expelled was also determined.

In *Pinus Strobus* this was found 41 cubic centimeters at the base, increasing to 59 cubic centimeters at 33 feet from the ground, then decreasing to 49 cubic centimeters at the top. The values for the south side exceeded those of the north side.

Bearing in mind the great regularity seen in the relations of the several parts to each other, one is led to suppose that, for the wood of the same tree at least, the *shrinkage* stands in direct proportion to the amount of air-space. But that each relation does not hold in passing from one species to another, can be readily seen by comparing the results. For *Pinus Tæda* and *mitis*, results similar to those of *Pinus Strobus* were obtained. There is first a rise from 43 cubic centimeters to 53 cubic centimeters, and then a gradual decline to 41 cubic centimeters in *Pinus Tæda*. In *Pinus mitis* a rise from 26 cubic centimeters to 40 cubic centimeters, followed by a decline to 30 cubic centimeters. For *Pinus glabra* and *Cubensis* the values are considerably oscillating, lying between 30 and 35 cubic centimeters on the north, and between 35 and 40 cubic centimeters on the south side for *Pinus glabra*, and between 30 and 40 cubic centimeters for *cubensis*.

The range of values of air-space was as follows:

Pinus Strobus	41–59
Pinus resinosa	30–36
Pinus mitis	26–40
Pinus Tæda	41–53
Pinus glabra	30–40
Pinus Cubensis	30–40

Many other determinations of this nature were made, all of which when properly amplified, classified, and placed in relation will give us a large amount of information for practical use, hitherto a sealed book.

There were also made measurements of the changing width of the several test-pieces during seasoning, and of the annual rings.

The general form of the trunk in all pines being the same, it is chiefly a comparison of their development on north and south side that interests us.

In *Pinus Strobus* the north side constantly excels the south side in thickness with great uniformity.

In the southern pines, on the other hand, Mr. Roth claims to have discovered a constant change in the amount of diameter development from north to south. It was impossible to determine, with the test pieces on hand, whether this oscillation in the development curve is a spiral one around the tree or in one plane. The near-lying supposition that a direct proportionality would exist between density and amount of growth or width was not borne out by comparison of the results obtained.

In counting and measuring the annual rings, for the purpose of bringing time and increase of volume into relation, usually three zones could be distinguished, which were most marked in *Pinus Tæda* and *mitis*, less so in *Pinus Cubensis* and *glabra*, and least in *Pinus Strobus*.

Taking the third section from the base as representing probably average conditions, the relation of these zones was found as follows:

	First zone (inner).		Second zone (middle).		Third zone (outer).	
	Number of rings.	Average width.	Number of rings.	Average width.	Number of rings.	Average width.
		mm.		*mm.*		*mm.*
P. Strobus	9	2.6	95	1.8	35	2
P. Tæda	10	5.8	15	4	13	2
P. mitis	11	5.2	25	3.4	16	2.1
P. Cubensis	16	3	32 rings 3^{mm}.			
P. glabra	9	6.6	20	4.5	12	3.1

In *Pinus Strobus* the second zone is not very sharply defined from the first; the rings in the middle zone are quite regular in width, the outer ones only becoming narrower and forming a transition into the outer zone, which consists of light-colored sap-wood.

This regularity in the middle zone indicates steadily increased growth, the width of the rings remaining constant for about one hundred and thirty to one hundred and forty years.

In *P. Tæda* this acceleration of the rate of growth is observed up to the thirty-first (?) year. The outer zone differs only by the width of its rings from the middle zone, but the transition is very abrupt, while the width of ring in either zone is quite constant. The inner zone is marked sharply by its darker colored wood. The same distinction is visible in *P. mitis.* In this tree a steadily increased accretion is noted for forty-five years.

In *P. Cubensis* the acceleration is continuous through the whole life of the tree under consideration.

In *P. glabra* the inner zone differs but slightly from the middle zone. Here, as in *P. Tæda* and *mitis*, there is an abrupt change in the rate of growth observable, which may be represented by an ascending curve, suddenly falling, and then ascending again in a direction parallel to the first incline.

Examining the width of rings in the different zones at different heights, we find, in general, the rings of the middle and outer zones steadily increasing in width from the base upward, becoming more and more nearly equal toward the top, until at last all difference vanishes, and with it the distribution of zones referred to before.

We may foreshadow some of the more practical results which seem to follow from these investigations by Mr. Roth, although the limited amount of material worked up will hardly warrant to base much generalization upon them.

While the other pines here considered grow far more rapidly when young, it seems highly probable that *Pinus Strobus* retains for a longer time the acceleration of growth in cross-section and is more regular in its total development.

It was stated before that the shrinkage is very nearly proportional to the amount of organic substance or the density of dry wood, since it is due to a loss of water, not from the cell-lumen but from the cell-wall. That this proportion is not always maintained is seen in the case of *Pinus Strobus*, where the density is greatest at the base, the shrinkage some distance from the base. The amount of water increases while the amount of organic substance decreases from base to top.

While in *Pinus Strobus* grown in the North the north side is more favorable to development than the south, the pines of the South do not show such relation to the direction of the compass.

Taxodium differs from the pines in nearly all the points determined. The growth is very slow—at least in the tree under observation—and

appears subject to periodic changes of growth and rest. The rings show a great abundance of summer wood, which makes them appear as if containing several rings. These intermediate rings varied from three to five, making the counting difficult and uncertain.

There were also numerous analyses made of the growth of these trees, which it would lead us too far here to give in detail. Let it suffice to give the following:

Comparing the two trees of *Pinus Strobus* and *resinosa*, which are grown under nearly the same conditions and with equal rapidity of height growth, and taking the fourth section as representing an average, the ratio of amount of organic substance per unit of volume being as 33 in *P. resinosa* to 31 in *P. Strobus*, the following comparison may be made, which shows *Pinus Strobus* a superior grower:

	First twenty years.	Next fifty.	Next forty.	Next forty.
	mm.	*mm.*	*mm.*	*mm.*
Pinus Strobus	2.9	2.5	1.6	1.3
Pinus resinosa	3.6	2.5	.87	.5
Ratio of wood growth	$\frac{1}{1.3}$	$\frac{31}{33}$	$\frac{1.7}{1}$	$\frac{2.3}{1}$

What has been here recorded of this work, just begun, does not claim to represent any wonderful results or discoveries, but has been simply related to show in what direction it is necessary to investigate our forest flora before we can begin to speak with more authority and on more exact foundation, not only of the properties of the various timbers, but also of the proper timbers to be grown in various localities and the methods of managing them.

These investigations, abstruse and simply of pure scientific interest as they may appear at first, are fraught with the greatest practical bearing on forest planting and forest management. They are of such a nature as to require their conduct under Government control, and should be engaged in by the Division in a more generous and far-reaching manner.

METAL TIES.

The interest which was stirred up among railroad men by the publication of Bulletin I from this Division has been further taken care of by engaging Mr. E. E. Russell Tratman, civil engineer, of Brooklyn, N. Y., to gather all information possible with regard to the use of metal ties in foreign countries. His preliminary report has just been submitted.* It shows that in several countries the metal tie has been adopted far beyond the limits of experiment. There may be estimated from the reports not less than 10,000 miles of metal track of various types in the world, the lion's share of this number belonging to Germany, with 5,530 miles. Next comes India, with about 1,800 miles; the Argentine Republic, with over 1,000 miles; Austria, Switzerland, and Spain, with each from 200 to 250 miles; Holland and Belgium, with 125 miles, and England, France, Africa, Egypt, Algeria, Mexico, and other countries with smaller amounts.

*This report will shortly be issued in Bulletin No. III, which will also embrace other matter of interest to railroad managers.

Out of 162,634 ties on the Netherlands State Railway, not one had broken. Of this one type, the "Post tie," there were in use in different countries about 730,000 ties, or 36,500 tons. In Algeria the saving of maintenance with metal ties has been calculated at about one-fourth, or $60 per mile.

The United States seems the most backward in experimenting with metal ties. This apathy will, however, presently cease, as the cost of wooden ties increases and the cost of manufacturing metal ties is reduced.

A seemingly perfect tie, just patented in this country by a Frenchman, A. Durand, civil engineer, is claimed to be produceable at the low rate of $1, including the fastenings.

TRADE NOTES AND STATISTICS.

Agreeably to the expressed wishes of lumbermen's associations it had been proposed to direct the energy of the Division towards ascertaining the remaining stock of merchantable white pine. As this stock-taking was to be made as thorough as it could be done, an appropriation of $15,000 for the purpose had been asked for, a sum only barely sufficient to produce reliable results.

The appropriation, however, failed to be made, and no statistical work was therefore attempted by the Division.

Some notes and gleanings of interest from various trade papers are given, in addition to the statistical tables of exports and imports, which are, as usual, compiled from the reports of the Bureau of Statistics.

While the tariff bill and free lumber, or retention of the duty, has been discussed in this country, Canada has increased the export duty on pine and spruce logs from $2 to $3. This is claimed to be a prohibitory duty, and since many American lumbermen have purchased timber limits over the line with the intention of sawing the logs in their mills on this side, the feeling in lumbermen's circles is strongly against this measure. Canadian lumbermen are said to be as much opposed to this duty as American, and claim it to be unconstitutional.

With reference to this question of retaliatory duty, one of the lumber-trade journals purports to show from the statistics that the export of logs from the United States to Canada is so much more in amount, six or seven times as much as those from Canada to the United States. Unfortunately the statistics are chosen with the object of proving the proposition. As I have shown in a table contained in my last report, the interchange of logs and round timber between the United States and Canada is almost equal in amount. The above-mentioned journal selects for the Canadian exports only those referring to pine timber, while for imports the entire line of goods, including hemlock, spruce, oak, etc., is included. The Canadian statistics allow a division of their exports into the different kinds, while the imports are lumped together.

The following tables reveal the true state of affairs :

Comparative statement of imports and exports for home consumption of home-grown wood and its manufactures, and of forest products between Canada and the United States for the year 1888.

CANADA.

Articles.	Duty collected in Canada.	Imports from United States.	Exports to United States.	Duty collected in United States.
(*a*) Logs and round timber	$21,651	$279,872	$383,675 *(790,250)	
(*b*) Lumber and timber (duty free)		515,172	809,497 (877,219)	
(*c*) Lumber and timber and roughly manufactured wood (dutiable)	42,652	184,670	8,581,827 (7,911,204)	$1,253,574
(*d*) Fire-wood		3,294	337,806 (364,412)	
(*e*) Tan-bark		903	246,568 (290,261)	
(*f*) Other forest products		97,540	263,114	
(*g*) Manufactures of wood	244,215	877,726	403,362	†144,861
(*h*) Carriages, wagons, cars	59,954	177,880	10,528	
Total	368,472	2,136,057	11,036,357	1,398,435

* Includes all logs imported into the country. Discriminations are not made in regard to this item in the returns.
† Duty estimated with 35 per cent. rate.

The following tables give specifications of some of the items lumped together in the above table:

Specified exportations into the United States from Canada.

Articles.	Value.	Articles.	Value.
(*a*) Logs:		(*c*) Lumber and timber (dutiable):	
Elm	$106,519	Pine deals	$416
Hemlock	18,383	Spruce and other deals	81,761
Oak	34,171	Deal ends	174
Pine	3,875	Lath palings, pickets	329,971
Spruce	99,450	Planks, boards, joists	6,831,950
All others	121,277	Scantling	148,894
(*b*) Lumber and timber (free):		Staves and headings	160,593
Railroad ties	514,789	Shingles	289,005
Stave bolts	118,701	Shingle bolts	738
Hop and hoop poles; Telegraph poles	146,750	Other lumber	517,988
		Box shooks	156,206
Knees and futtocks	19,858	Other shooks	57,874
Masts and spars	9,204	Square timber	5,537
Basswood, butternut, hickory, etc., unmanufactured	195		

Specified importations into Canada from the United States.

Articles.	Total importations.	Importations from the United States.	Articles.	Total importations.	Importations from the United States.
(*b c*) Lumber and timber, planks and boards, sawn, not manufactured:			(*g*) Manufactures of wood:		
Box, cherry, chestnut, gum, hickory, and whitewood	$55,332	$55,332	Furniture	$238,745	$215,205
Oak	98,547	98,514	Caskets and coffins	3,498	3,498
Pitch pine	68,616	68,013	Hubs, spokes, parts of wheels	11,139	11,139
Redwood	246	246	Moldings, plain	4,180	4,180
Hickory	32,216	32,216	Moldings, finished	31,739	31,482
Walnut	258,250	258,250	Show cases	2,520	1,952
(*g*) Manufactures of wood:			Wooden-ware	41,186	41,135
Barrels	242,034	233,830	Picture frames	27,937	17,593
Clothes wringers	5,424	5,410	Pipes, tobacco (wooden)	104,138	7,888
Fishing rods	6,474	3,955	Veneers	38,268	38,268
			Other manufactures	431,743	373,805
			Total	1,702,232	1,501,501

NOTE.—The above tables are made up from the "Tables of Trade and Navigation for the Dominion of Canada." The figures in parenthesis are from the reports of the United States Bureau of Statistics and differ somewhat from the Canadian returns.

The position, then, of the lumber trade between Canada and the United States at present appears from these and the subsequent tables to warrant the following statements: The bulk of forest products and wood manufactures which we import comes from Canada, while we return less than 10 per cent. of our own exports of the same kind to that country. This export consists in nearly equal shares of raw material and manufactures. Of the latter we supply almost all that Canada can take, our exports of this class of goods representing nine-tenths of the total importations of the same into Canada. Our importations from Canada represent about 50 per cent. of all exports of the kind from Canada and consist mainly of manufactured lumber. All the wood material thus imported does not count up to 75,000,000 cubic feet, or, very roughly speaking, not to one-third of 1 per cent. of our total consumption. As to logs on which duty is collected, only spruce logs cut any figure, with less than $100,000. The kind of logs imported into Canada from the United States is not specified, but assuming that all going to Ontario and Manitoba are pine, these represent the value of $255,406, or the largest share of the log trade.

Comparison with the condition of trade ten years ago shows an increase of Canadian imports of forest products to the United States of 137 per cent., while exports from the United States to Canada have hardly changed perceptibly during that time.

Altogether it would appear that while Canada has every reason to encourage lumber trade into the United States, she does not offer a sufficient market to influence our forest policy.

It is also admissible to argue that the one and a quarter million dollars of tariff duty which our people pay on eight or nine million feet of lumber coming from Canada can have but little significance and offer but small protection to an industry producing not less than (round) 10,000,000,000 feet of lumber, which may be estimated to represent the cut of white pine and spruce together—the only kinds with which Canadian imports come into competition.

As regards the "inexhaustible" white pine supplies, the lumbermen's papers are becoming more and more doubtful. The *Northwestern Lumberman*, the paper which led the opposition to all "denudatic" theories, lately brings the following significant editorial:

> The great study nowadays on the part of lumbermen in Michigan, Wisconsin, and Minnesota, while the pine is fading away, concerns the avoidance of waste and the utilization of all the timber in some way. Even wormy pine is being cut in large quantities by Saginaw Valley lumbermen this winter. Its manufacture into lumber is a special industry in itself, as the product can be readily marketed for certain purposes to which it is adapted, including glass-box shooks, heads for crockery casks, coarse fencing, etc. A large demand for this class of lumber is found at Pittsburgh, Pa.

The paper quoted above also states that "the quality and size of pine is depreciating in ratio with the progress of cutting and manufacture." "The time is not far distant when good pine will be positively scarce."

Another paper expresses itself as follows:

> If anything were lacking to demonstrate the fact that 'the beginning of the end' of the pine timber of Michigan has become a fixed and palpable reality, a single glance at what may be termed saw-logs, for compliment's sake, as they are towed down the Saginaw River from the Tittabawassee boom to the mill booms, would at once supply the missing link in the chain of evidence amounting to an ocular demonstration. Many of these rafts are composed of veritable poles which are hardly worthy the name of saw-logs and barely sufficient in size to produce a piece of 4 by 4 timber.

The same paper remarks on the celebrated Muskegon supplies:

Two years ago or thereabouts, the prediction was made that 1886-'87 would be the last one in which a big cut of logs would be made on the Muskegon River. It is plain now that it will be abundantly fulfilled. Present estimates of the coming winter's input on that stream indicate that the cut will fall from 60,000,000 to 80,000,000 behind last year, and will probably but little exceed 400,000,000 in all. As a matter of fact it can be easily discerned that the beginning of the end is already at hand on the Muskegon, and that its history from this time forward will be that of a more or less slowly decreasing production. There is practically no standing pine to be bought tributary to its waters. The probability is, that within a couple of years mills will have finished their work there, to make a difference of nearly 50 per cent. in the output as compared with the minimum figure reached. This decrease will be missed seriously, for there is no source from which an equivalent supply can be drawn to make it up, unless the Georgian Bay region of Canada should be thrown open by a removal of the duty.

The increasing value of pine lumber may be pretty accurately understood when the price of culls is considered. Within two years culls have actually doubled in value, and it is not very many years since culls were burned under salt-pans which would bring big money to-day.

The present year (1888) has seen the largest cut of white pine lumber as yet experienced. According to the compilations of the *Northwestern Lumberman* it amounts to 8,388,716,460 feet, B. M., and 4,514,646,801 shingles. This is an increase of 7½ per cent. over last year's cut, which is a larger proportionate increase than has been observed since 1882.

There is a great deal of activity developed in getting hold of the timber growing on Indian reservations, the desire of obtaining this valuable property at low rates animating one side, and the desire of protecting the Indian in his rights and securing to him a fair return the other side; these two aspects being the only considerations which seem to count in the policy to be pursued. The desirability of keeping these lands as Government forest reserves, which has been advocated by some wise and patriotic men who contemplate something else than the mighty dollar as a nation's interest, seems to have no place in the discussion or disposal of this question.

The above mentioned paper relates a conversation with a manufacturer of butter packages, stating that it had become difficult to procure sufficient northern white ash, and adds:

This man's need of course cuts but very little figure in the general demand for ash, but his declaration emphasizes the fact that northern ash is getting scarce, that future supply must come from the South.

The growing scarcity of hickory and ash for suitable carriage manufacture has induced the Carriage Manufacturers' Association to appoint a committee for the purpose of investigating the condition of these supplies.

A writer conversant with southern timber resources calls attention to the rapidly increasing demands upon yellow pine supplies, and says: "Ere twenty years expire we may look around with cold statistics to back us in vain for these vast and rapidly disappearing forests of pine."

Another man, who knows whereof he speaks, thus dilates upon the Southern pine forests:

We need help in the development of the South, yet I could wish and it would be justice itself, if those of us who have borne the burden of these times of depression in the South could hold on to enough of our natural wealth to make us independent of this incoming tide of investors. * * * Further investigations will show that the general estimates as to the quantity of the yellow pine and other timber in the South have been exaggerated, and a canvass of the timber tracts will show a lesser average number of feet to the acre than has been universally reported.

I believe those people who have gotten into their heads the idea that the supply will be unlimited for the coming generations will arrive at a wiser conclusion as the days and years of their lives come on apace.

In regard to the timber resources of the Pacific coast, which have only just begun to be appreciated, we hear the following from the editor of the Humboldt, California, *Standard*, situated in the heart of the redwood operations:

How the mighty have fallen! The 200-feet-to-first-limb-straight-as-a-ship's-mast-to-a-height-of-300-feet-7-foot-in-diameter trees are not so plenty as they once were; the once common 40-foot-in-diameter redwood trees no longer thickly stud our forests. Alas! our matchless redwood forests are melting away before the woodman's ax and the ravenous tooth of the saw, like snow under the tropical sun. A score of years hence scarcely a vestige will be left, and our people will know and appreciate its great value.

The lumber export business from the Pacific coast is increasing every year. Redwood forms the great staple of San Francisco shipments. During the year 1888, according to "*Wood and Iron*," the shipments amounted to 27,656,941 feet, B. M., valued at $749,923. Most of this goes to Australia and Pacific islands, the market for redwood in the Eastern States being still of small dimensions. Overland shipments to the East amounted to 4,379,961 feet, valued at $131,370.

The shipments from Puget Sound are somewhat larger, consisting mainly of red fir and Port Orford cedar. The total output of lumber for the year 1888 is computed at 409,961,270 feet, mostly rough lumber, valued at $6,759,580. Australia forms the best export market.* Local demand for box factories, furniture, and wagon manufactures is brisk. California, especially San Francisco, takes the largest share of the coastwise trade, and Denver, Salt Lake, Ogden, and small towns in eastern Oregon, Washington, and Idaho, take over 20,000,000 feet. Ship-building is reported as very active at the sound, twenty vessels with a tonnage of 4,225 having been completed this year, and the business outlook for lumbermen is bright. The exports have increased about 50 per cent. during the year, amounting in 1888 to $1,091,148, representing besides shingles, laths, pickets, and spars, 113,775,000 feet of boards.

*The shipments to Australia this year amounted to 55,487,694 feet, B. M., as against 24,515,087 feet, B. M., last year.

*Imports of forest products and manufactures of wood, and increase or decrease of the same for the years ending June 30, 1878, and 1888.**

Articles.	1878. Quantity.	1878. Value.	1888. Quantity.	1888. Value.	Increase. Value.	Increase. P. ct.	Decrease. Value.	Decrease. P. ct.
Free of duty.								
Fire-wood ....cords..	117,746	$225,759	181,263	$364,413	$138,654	61.4	....	.....
Logs and round timber ..	....	168,665	....	790,251	621,586	368.5	....	.....
Railroad ties............	....	176,057	3,234,391	663,242	487,185	276.7	....	.....
Shingle and stave bolts..	....	27,809	....	137,787	109,978	395.5	....	.....
Ship timber........tons..	3,515	20,687	....	39,758	19,071	92.2	....	.....
Ship planking............	....	13,278	....	30,548	17,270	130.	....	.....
Hop poles................	....	....	....	5,884	....	....	....	.....
Wood pulp	....	268	....	21,263	20,995	7,834.	....	.....
Charcoal......... tons..	35	170	6,571	50,832	50,662	29,801.	....	.....
Hemlock bark....cords..	105,781	412,259	62,926	290,261	....	....	$121,944	29.5
	....	1,044,952	....	2,394,239	1,349,287	129.1	....	.....
Dutiable.								
Wood, unmanufactured, not elsewhere specified.	....	6,321	....	14,238	7,917	125.	....	.....
Timber........cubic ft..	61,534	7,799	23,720	3,283	....	....	4,516	57.9
Lumber:								
Boards, planks, deals, etc.......... ..M. ft..	279,700.75	2,752,632	536,195,349	6,526,172	3,773,540	137.	....	.....
Clapboards.........M..	979.43	8,254	3,113,546	43,809	35,555	430.5	....	.....
Hubs, posts, lasts, and blocks....	....	53,953	....	39,561	....	....	14,392	26.6
Laths ....M..	108,975.37	97,416	246,373,791	306,121	208,705	214.2	....	.....
Pickets and palings.M..	3,053.87	21,185	7,374,628	58,973	37,788	178.3	....	.....
Shingles............M..	47,610.19	97,501	160,313,117	331,329	233,828	239.8	....	.....
Shooks and packing boxes ....No..	....	14,774	....	185,314	170,539	1,154.3	....	.....
Staves ....do....	547,989	8,733	....	419,925	411,192	4,708.6	....	.....
Bark extracts, chiefly hemlock	....	5,244	....	1,094	....	....	4,150	79.
Sumac:								
Ground ....lbs..	15,068,581	508,247	13,735,981	276,209	....	....	238,038	46.8
Extract	....	9,048	2,600,324	92,678	83,630	924.3	....	.....
Matches..................	....	2,437	....	20,567	18,130	744	....	.....
Casks and barrels........	....	2,259	....	1,985	....	....	274	12.1
Cabinet ware and furniture	....	97,284	....	355,116	257,832	265	....	.....
Osiers and willows.......	....	15,966	....	18,366	2,400	15.6	....	.....
Osier and willow baskets, etc..............	....	91,445	....	334,007	242,562	26.5	....	.....
All other manufactures..	....	507,187	....	498,057	....	....	9,130	1.8
	....	4,307,685	....	9,526,804	5,219,119	121.1	....	.....
	....	5,352,637	....	11,921,043	6,568,406	122.7	....	.....
Free of duty.								
Cabinet woods:								
Box	....	30,137	....	51,440	21,303	70.6	....	.....
Cedar	....	160,540	....	361,106	200,566	124.9	....	.....
Ebony	....	41,875	....	37,361	....	....	4,514	10.78
Granadilla	....	351	....	898	547	155.8	....	.....
Lancewood	....	4,002	....	17,566	13,564	338.9	....	.....
Lignum-vitæ..............	....	56,124	....	40,735	....	....	15,389	27.4
Mahogany	....	80,165	....	605,875	525,710	656.2	....	.....
Rose	....	93,000	....	21,624	....	....	71,376	76.7
Sandal	....	138	....	4,217	4,079	2,956	....	.....
Satin....................	....	....	....	9,237	....	....	....	.....
All other cabinet woods	....	188,813	....	266,683	77,870	41.24	....	.....
Cork-wood or bark, unmanufactured	....	495,316	....	1,063,861	568,545	114.8	....	.....
	....	1,150,461	....	2,480,603	1,330,142	115.6	....	.....
Total..............	....	6,503,098	....	14,401,646	7,898,548	121.4	....	.....

* By the act of March, 1883, the cost of transportation, shipment, transshipment, with all the expenses included, from the place of growth, production, or manufacture, to the vessel in which shipment is made to the United States; the value of sacks, crates, boxes, etc., in which the merchandise is contained, commission, brokerage, export duty, and all other usual charges which prior to that act formed a part of the dutiable value of imports, are excluded from the same. This needs to be taken into account in comparing the value of goods imported prior to and subsequent to that date. It would probably carry the valuation of imports for 1888 to $18,000,000, or nearly three times that of 1878.

Exports of forest products and manufactures of wood, and increase or decrease of the same, for the years ending June 30, 1878 *and* 1888.

Articles.	1878.		1888.		Increase.		Decrease.	
	Quantity.	Value.	Quantity.	Value.	Value.	P. ct.	Value.	P. ct.
Fire-wood ....cords..	2,837	$9,469	3,164	$10,511	$1,042	11.	....	......
Boards, deals, and planks, M. ft. ....; Joists and scantling......do...	313,143	4,531,741	447,423	7,322,249	2,790,508	61.6	....	......
Hoops, hoop-poles, etc	....	377,137	....	161,853	....	......	$215,284	57.
Laths ....M..	3,050	9,233	10,579	27,231	65,640	711.	....	......
Palings, pickets, and bed-slats, M.			1,897	47,642				
Shingles ....do.	46,518	154,533	33,932	104,362	....	......	50,171	32.5
Shooks, box	....	142,610	....	157,637	15,027	10.5	....	......
Shooks, other ....No..	....	3,778,196	668,972	830,113	....	......	860,545	22.8
Staves and headings.......do..	....		....	2,087,538				
All other lumber	....	520,454	....	1,756,083	1,235,629	237.4	....	......
Timber, sawed .....cub. ft..	18,261,915	2,662,784	*187,780	2,331,050	638,708	24.	....	......
Timber, hewed ....do....			5,813,175	970,442			....	......
Logs and other timber	....	352,104	....	2,027,496	1,675,392	475.8	....	......
Total raw material and partly manufactured..	....	12,538,261	....	17,834,207	6,421,946	51.2	1,126,000	8.9
Rosin, tar, and turpentine, bbls	1,042,183	2,329,319	1,533,323	2,349,801	20,482	0.87	....	......
Spirits of turpentine ...galls..	7,033,568	2,333,569	10,585,942	3,580,106	1,246,537	53.4	....	......
Bark and tanning extracts....	....	111,335	....	254,204	142,869	128.3	....	......
Total by-products	....	4,774,223	....	6,184,111	1,409,888	29.5	....	......
Hogsheads and barrels, empty, No.	82,402	159,420	....	502,556	343,136	215.2	....	......
Household furniture	....	1,961,522	....	2,335,569	374,047	19.	....	......
Wooden ware	....	287,861	....	293,064	5,203	1.8	....	......
Doors, sash, and blinds†	....	....	....	323,023	323,023	......	....	......
Moldings, trimmings, etc......	....	1,714,140	....	102,220	102,220	......	....	......
All other manufactures	....		....	1,699,695	....	......	14,445	0.84
Matches	....	143,219	....	72,371	....	......	70,848	49.4
Agricultural implements.No..	31,397	2,575,198	....	2,645,187	69,989	2.7	....	......
Musical instruments	....	756,477	....	908,540	152,063	20.1	....	......
Carriages, carts, and parts of.	....	979,003	....	1,381,291	402,288	41.	....	......
Cars, railroad, passenger, and freight ....No..	657	532,840	794	862,465	329,625	61.8	....	......
Billiard tables and apparatus .	....	18,983	....	31,670	12,687	66.8	....	......
Total manufactures	....	9,128,603	....	11,157,651	2,114,281	23.1	85,293	0.93
	....	....	....	....	9,946,115	37.62	1,211,293	4.58
Total	....	26,441,147	....	35,175,969	8,734,822	33.03	....	......

* Thousand feet.
† Until 1884 the reports of doors, sash, blinds, moldings, trimmings, etc., are included by the Bureau of Statistics in "All other manufactures," and can not be given separately.

Imports of forest products and manufactures of wood, and countries from which imported, during the year ending June 30, 1888.

Countries.	Log-wood in sticks.	All other dye-woods in sticks.	Gums.	Cork, wood or bark.	India rubber and gutta-percha.	Sumac.	Bark, hemlock, and extracts of.	Wood, unmanufactured, not elsewhere specified.	Boards, plank, deals, etc.	Shingles.	Other lumber.	Cabinet-ware and furniture.	All other wood, manufactured.	Amount from each country.
Africa		$23,477	$109,195		$195,987			$12,388						$341,047
Australia			1,227,224					452	$90				$310	1,228,076
Austria		217	169,136			$258		5,136				$68,514	54,205	297,466
Brazil	$6,360	8,665	269		10,811,952			36,204						10,863,450
British North America	170	17	5,618		1,799		$290,261	2,055,995	7,497,078	$331,299	$1,066,997	1,576	131,157	11,381,967
British Guiana			1,351		2,397			620						4,368
Central American States		2,496	5,697		1,092,465			19,593				291	15	1,120,557
Dutch Guiana					36			609						645
East Indies		1,354	2,027,694		392,338			576,453				1,915		2,999,754
Ecuador					327,477									327,477
England		8,734	949,327	$1,794	1,916,790	1,388		108,152	2,532		531	84,249	12,702	3,086,199
France			285,455	15,151	107,400			88,360			1,100	136,344	162,308	796,118
Germany			37,594	414	229,844			66,003			119	18,613	585,285	937,782
Hawaiian Islands													411	411
Italy			12,802	304		261,519		13,970			1,445	20,847	15,175	326,062
Japan			258,906					18,318				466	67,518	345,208
Mexico	99,073	61,324	295,539		131,224			537,600	514			152	739	1,126,165
Netherlands			17,178		229,078			1,280				1,474	6,623	255,633
Portugal			346	806,546	180,035							18		995,945
Spain		677		253,442								229	471	254,819
Turkey			39,765					5,681				634	1,830	47,910
United States of Colombia		3,554	381		388,691			47,592					194	440,412
Venezuela		10,849	375		22,688			31,609					46	65,567
West Indies	1,429,706	14,840	14,384		27,089		400	498,045	15,489			390	1,235	2,001,578
All other countries			65,943	2,123		1,563		41,813			1,207	9,153	84,664	206,466
Total	1,535,309	136,204	5,524,089	1,079,774	16,066,290	264,728	290,661	4,165,873	7,515,703	331,299	1,071,399	344,865	1,124,888	39,451,082

Exports of forest products and manufactures of wood, and countries to which exported, for the year ending June 30, 1888.

Countries.	Agricultural implements.	Bark, and extract of, for tanning.	Matches.	Turpentine and rosin and spirits of turpentine.	Boards, deals, and planks.	Joists and scantling.	Hoops and hoop-poles.	Laths, palings, pickets, etc.	Shingles.	Shooks, box.	Shooks, other.	Staves and headings.	All other lumber.
Argentine Republic	$877,519			$137,949	$1,313,801	$48,961		$2,919	$582	$16,137	$36,423	$2,680	$30,512
Australia	239,439	$2,169	$6,725	121,431	809,798		$420	36,188	2,852	4,029		9,021	127,494
Austria	4,539			99,867	1,107							1,445	
Belgium	5,670	23,976		399,291	115,637						84	19,438	2,250
Brazil	20,354		589	98,310	290,840	2,974	452			4,237	705	617	591
British North America	99,012	240	4,169	126,783	267,134	768	680	211	153	10		60,306	124,472
Central American States	5,817		5,306	8,375	51,282	196	6	187	6,596	3,670	270	75	3,626
Chili	65,891			39,415	182,424	148		1,388		3,600	180	21,671	4,304
China				10,961									210
Denmark	4,712			7,300			175					440	2,960
England	359,619	71,425		2,495,602	723,001	715	488	153		6,762	58,361	358,526	556,370
France	235,731	39,588		11,907	186,089							61,635	5,846
Germany	198,609	75,600		677,385	126,162		1,400			900		31,920	84,000
Hawaiian Islands	9,296		1,090	1,482	158,845			978	21,592	1,168		1,536	3,447
Hayti	188	183	5,479	4,216	150,290	2,203			7,043	4,399	450		8,374
Italy	16,901	655		147,011	165,688					51,392		125,091	5,121
Japan	2,536	605	1,452	6,955						100			
Mexico	25,365	346	2,438	5,793	362,129	27,808	170	532	12,838	9,489	141	647	407,431
Netherlands	7,914	21,252		617,930	169,903							54,465	19,213
Peru	9,676		30	22,265	65,418				12	4,323	150	8,032	6,668
Portugal	4,333	3,350		19,114	34,575	308					76	316,110	910
Russia	97,140		8,334	169,546									
Scotland	26,646	10,841		263,838	153,548	13,225					280		134,308
Spain	285			22,143	118,278	13,378	1,000			2,457	1,444	541,782	3,986
United States of Colombia	2,537		14,003	12,528	236,254	96	46	24	2,558	2,085	47	65	16,192
Uruguay	66,788			49,211	324,110	6,531		3,757		25			39,269
Venezuela	1,300	134	1,845	20,434	13,634	397	312	23		455	687	1,285	3,636
West Indies	50,924	3,781	11,327	47,046	828,455	38,198	155,669	1,270	46,859	32,342	695,150	261,125	59,561
All other countries	445,784	19	9,584	285,986	372,687	6,344	1,033	12	3,274	10,017	35,470	143,921	105,332
Total	2,884,525	254,157	72,371	5,930,074	7,161,079	162,250	161,851	47,642	104,359	157,597	829,918	2,021,833	1,756,083

Exports of forest products and manufactures of wood, and countries to which exported, for the year ending June 30, 1888—Continued.

Countries.	Timber, sawed.	Timber, hewed.	Logs and other timber.	Doors, sash, and blinds.	Moldings, trimmings, etc.	Hogsheads and barrels, empty.	Household furniture.	Wooden-ware.	All other.	Total to each country.
Argentine Republic	$62,978			$1,406	$1,949	$4	$279,460	$9,260	$31,931	$2,854,480
Australia	217,113		$1,110	135,074	20,265	266	165,546	54,864	242,007	2,196,001
Austria	7,978						200		1,355	116,491
Belgium	12,755	$32,382	164,817			163	34,789	1,352	8,594	821,198
Brazil	4,012		7,160	361	320		54,375	4,134	13,717	503,748
British North America	76,778	309,418	161,829	21,225	12,883	13,183	260,955	24,875	245,679	1,810,163
Central American States	35,312		6,181	6,364	735	203	62,892	1,194	26,371	224,658
Chili	320		300		1,266		38,742	2,982	22,170	384,801
China	1,302			973			6,358	14	547	20,365
Denmark			1,142				5,112	243	4,181	26,265
England	745,765	390,672	586,548	30,650	33,806	11,111	376,674	108,859	408,028	7,323,135
France	118,886	70,205	74,289			351	95,672	8,032	41,124	944,355
Germany	41,912	19,829	788,725		874	5,600	175,413	13,719	144,238	2,386,286
Hawaiian Islands	10,452		1,137	0,392	3,134	1,146	62,576	4,740	36,441	329,452
Hayti			56	1,134	140	856	46,338	1,880	6,748	239,975
Italy	169,263	13,347	16,293				36,134	785	7,528	755,209
Japan							16,388	19	4,215	32,270
Mexico	222,228	115	34,097	12,899	3,834	6,554	138,322	6,299	34,593	1,314,008
Netherlands	117,557	38,150	32,809			643	8,323	996	18,456	1,047,614
Peru			4,587		1,498	335	12,242	643	4,713	140,531
Portugal	41,765	7,041	40				2,785	48	700	431,135
Russia	79						1,883		5,302	282,284
Scotland	259,800	47,104	110,385	516	1,936	12,811	23,505	15,638	108,002	1,182,376
Spain	10,805		495				4,711	787	4,587	726,138
United States of Colombia	23,270		18,346	8,295	2,492	190	88,012	11,413	48,194	486,587
Uruguay	3,695				698		26,853	880	6,364	528,881
Venezuela			6,100	319	412	1,431	29,090	1,868	13,111	96,466
West Indies	12,732	232	3,803	6,509	10,560	445,511	161,173	17,827	107,054	2,997,103
All other countries	134,093	41,947	7,247	86,906	5,458	2,195	121,037	4,710	104,258	1,927,314
Total	2,331,050	970,442	2,027,496	323,023	102,220	502,556	2,335,569	293,064	1,699,695	32,128,854

England leads the list of countries to which we ship the largest amounts, closely followed by the West Indies: the Argentine Republic comes next, and then Austria, Germany, and Canada, with almost equal participation in our export trade.

In wood manufactures, which form less than one-quarter of our exports of forest products, agricultural implements and household furniture alone are of significance, each with about $2,000,000 worth.

England, France, the Argentine Republic, Austria, and Germany together take over two-thirds of our wood manufactures. France and the Argentine Republic are the best markets for agricultural implements.

The cooperage industry finds its best customers in the West Indies with over $1,000,000 worth of goods. Spain and Portugal come next with together three-quarters of a million, and England with somewhat less than half a million. It is noteworthy that we furnish to France, which imports yearly from 35,000,000 to 40,000,000 staves, not as much as $100,000 of our cooperage, while Italy, through whose territory by way of Trieste and Fiume France receives the largest part of her need of staves, from Hungary, yet allows us to dispose of almost $100,000 of cooperage to her.

Our imports have increased during the year by somewhat over $1,000,000, without specially noteworthy features in the distribution of this increase.

The table of imports from various countries shows that British America is the only country which comes into competition to any extent with our native forest products in raw shapes, while Germany, Austria, France, and England send us somewhat over $1,000,000 worth of wood manufactures. Nearly two-thirds of our imports of forest products are, like India-rubber, gums, cork, dye-woods, cabinet-woods, not produced in our country.

Our exports have increased during the year by over $3,500,000, or 12½ per cent. This increase is largely represented in raw material, logs, and hewn timber to the amount of $200,000; boards, deals, etc., $1,300,000; while manufactured articles take part in the increase with only (round) $800,000.

The largest exports of raw material are in manufactured lumber and in naval stores; the next largest in cooperage, timber, and logs.

The shipments of lumber to Great Britain have been considerably above those of former years. According to the trade reports of that country we shipped the following quantities to England during the under-mentioned years:

Years.	Quantity.	Value.
	Cubic feet.	
1886	15,514,350	$4,370,515
1887	14,403,300	4,485,930
1888	17,475,000	5,714,670

Walnut shipments were especially heavy, often of doubtful quality and therefore sold at a sacrifice. Hamburg, Germany, imported of this staple over 10,000,000 feet or almost double the amount of last year.

If we add cooperage to lumber and timber, the West Indies prove almost as good customers as England, the latter country swelling the amount by its large importation of naval stores, which repre-

sents almost 40 per cent. of its importation of forest products from us, and also nearly 40 per cent. of our total exports of naval stores; Germany, the Netherlands, Belgium, and Brazil, together taking another 36 per cent.

The total imports of sawn and hewn timber into Great Britain for the last four years, according to the detailed statistics given by the *Timber Trades Journal* of London, England, were as follows:

	Cubic feet.
1885	308,248,950
1886	268,059,600
1887	275,451,000
1888	311,008,450

Of these amounts, we furnished 7 and 6 per cent., respectively, in 1887, 1886, and 1885; but, although we have shipped more lumber and timber to England this year, our proportion of the whole importation has fallen below 6 per cent. Nearly one-half of this comes from our southern ports in the shape of yellow-pine timber and lumber, namely, from Pensacola, Fla., alone, 8,105,450 cubic feet. From the same port there were shipped, in addition, to other countries and coastwise, nearly 14,000,000 cubic feet.

CULTURAL NOTES.

During the year a great many letters asking specific advice in regard to the cultivation of different trees, methods of starting groves, management of natural growth, etc., have to be answered by the Division, and give rise to the collection of notes and information on subjects, some of which are here embodied.

Perhaps the most notable advance in the field of forest culture which has been made lately is the application of mechanics to tree-planting. It may indeed prove the turning-point for practical forest planting in the prairies and plains that a machine has been invented capable of breaking the ground and setting and planting from 20,000 to 30,000 seedling trees, all in one motion.

This machine is of exceedingly simple construction, and in its results, having been tested for two years, seems to be superior not only in the quantity but also the quality of work.

It was in its first form a child of necessity. Thomas A. Stratton, a farmer near Lincoln, Nebr., originally from the Buckeye State, having a tree claim in southwestern Nebraska, at Stratton, 70 miles west of the one hundredth meridian, found himself, in the spring of 1886, with 100,000 two and three year old seedlings on hand and no chance of hiring the labor for planting the same. He devised and constructed the tree-planter with his own hands, and begun planting on April 17—planting, with the aid of one man, and five horses abreast, the entire 100,000 trees in eight days, most of the ground being unprepared, a small part only having been back-set.

The 22d of April was Arbor Day, and Mr. Stratton set 11,200 trees, handling every tree himself in order to obtain the premium "for the greatest number planted by one man." Of these, according to affidavit of witnesses, 95 per cent. were alive and growing in October of the same year (see Annual Report Nebraska State Board of Agriculture, 1886, p. 49) and are now (1888) in thrifty condition. On other days, when driver and feeder changed hands, as many as 15,000 trees were set, and with the improvements since made one

man has set, in nine hours, 15,272 ash seedlings—on Arbor Day, 1888. With more help and further improvements, now made, the machine will be capable of preparing ground and planting in a thorough manner from 20,000 to 30,000 plants or more.

The machine is drawn by five horses abreast. The coulter and coulter-plow (C and D) cut the prairie sod in advance of the large furrow-plow (D^4) which opens a furrow 6 inches wide (or wider if wanted) and from 10 to 15 inches deep, the depth being regulated by means of a lever (N) operated by the driver, and the furrow being kept open by extension of the landsides. By the side of the planting-wheel, which is propelled by walking on the ground as the machine moves (walking sticks G), are seats for the feeders (R and R^1), and by their side are boxes for carrying plant material (P) enough to plant a row half a mile long, 4 feet apart. The plants are fed to automatically-acting grapples or clamps (G^3) attached to the planting-wheel. The distance of the plants is regulated by the number of grapples on the planting-wheel which are being used. In the new machine, the grapples on each spoke, which are to receive the plants, are kept open by means of a disk and springs until they pass a given point on the upper side of the wheel; before this is reached the plant is inserted with the roots pointing upwards into a holder (I) where it is found by the grapple which takes it up and closes, holding the plant until it is brought around and down into the furrow, when the grapple opens automatically and drops the tree. At that moment two shovels (J), following closely, fill soil around the plant and close the furrow. The hind wheels represent two 6-inch-face rollers, set somewhat obliquely to press the earth firmly against the plants. The superior success of the planting by this machine on raw prairie as against ordinary methods on prepared ground, which has been observed, must be ascribed to these rollers, which bring roots and soil in closest contact, the most essential requisite in tree planting, most especially in a dry climate.

It is of course not necessary, as was done in the first instance, to plant into the raw prairie, although this experience has shown that it can be done successfully. The better plan would be, where the ground is light and dry and covered with buffalo-grass, as in the western parts of Nebraska and Kansas and in eastern Colorado, to cut the sod in the spring as soon as the ground is in condition, and break the ground with a coulter-plow, following with a disk-harrow to break the sod fine, then do the planting at once in trenches or with the planter.

In this way the plants are placed in a soil which has had no chance of drying out; all rains penetrate easily and collect in the trench in which the plants stand, and the sod forms a mulch which helps to prevent evaporation. The new ground being free from weeds, makes cultivation unnecessary, and the plants, if planted 4 feet apart and of good growth, will soon cover the ground sufficiently to subdue the incoming weeds. This method of planting, which I proposed two years ago, after having inspected the conditions of tree planting in the West, though probably not applicable to all conditions, has been fully proved correct by the experience of Mr. Stratton during the last two years, since he used his tree-planter. He writes: "I would rather plant trees on new ground in the above manner and let them remain uncultivated than to plant trees in old ground deeply cultivated, full of weed seeds, and then to cultivate the trees; the result would be in favor of new ground and no cultivation."

Fig. 1.

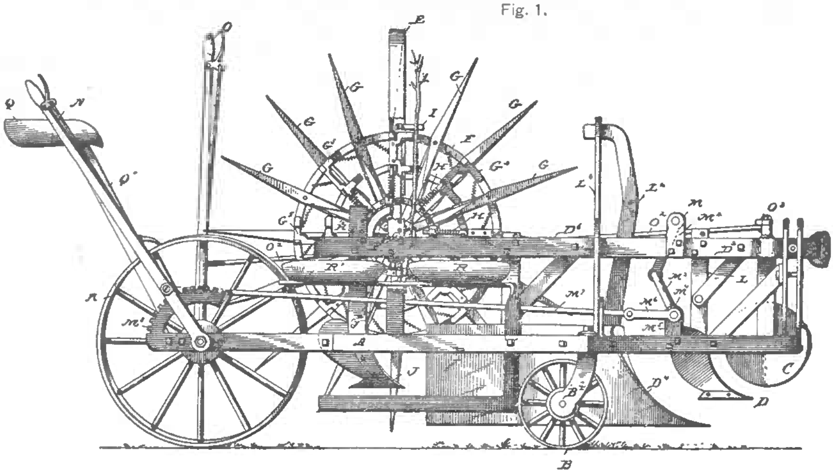
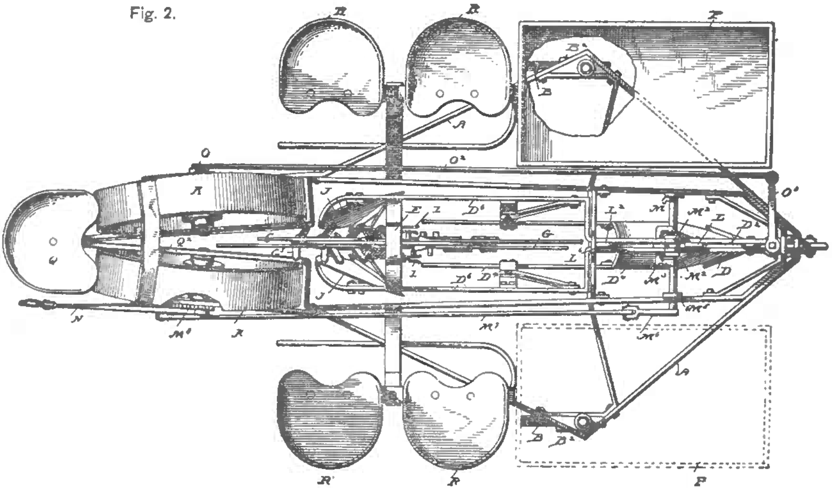


Fig. 2.



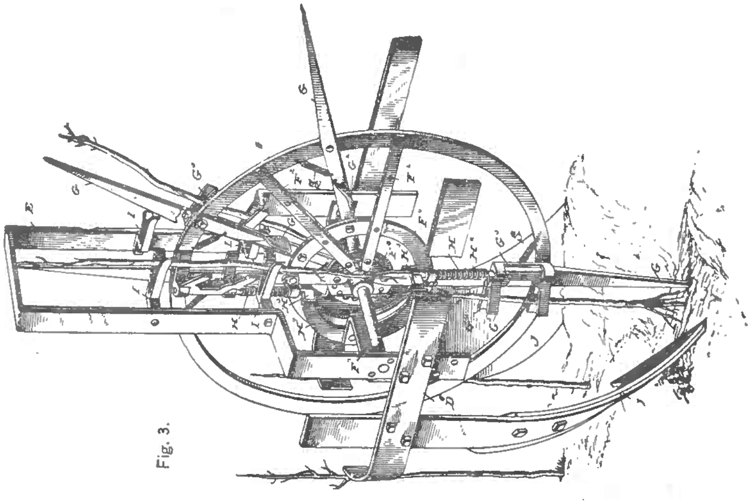


Fig. 3.

Mr. Stratton figures that one ordinary traction-engine arranged for drawing plows will operate 3 plows, 1 harrow, and 1 tree-planter, attended by two men only, planting trees 4 feet apart each way, at the rate of 6 acres per day, if properly managed. And as there are ordinarily at least sixty days in the spring time for tree planting, two men can plant 360 acres during the spring season with this machinery; with more help the amount of planting could, of course, be increased within limits.

That this tree-setting machine may be adapted to the planting of tobacco, cabbages, beets, etc., need not be further elucidated.

At present writing the machine is not yet in the market, but it is understood that during the coming summer its manufacture will be begun.

FOREST FARMING.

There are several methods in vogue of combining agricultural use of the soil with forest planting, with a view both of cheapening the planting and benefiting the plants.

Probably the need of agricultural lands for the poorer population rather than any other consideration has in Germany early given rise to this combination of forestry with a temporary agricultural use of the forest land.

That such use of clearings before their reforestation may prove an advantage to the new forest growth and be employed to cheapen and facilitate reforestation was probably an after-thought. In devising methods for prairie planting this practice deserves more consideration than it has hitherto found.

Such agricultural use of the land either precedes reforestation or is continued for a time after the tree-planting has been done. We may call the first plan "fore-farming," the second plan "between-farming." The "fore-farming" is usually carried on for one to six years, the "between-farming" up to six years.

A common rotation of crops is rye, potatoes or millet, oats; and then oak, pine, and spruce sown with the oats or planted on the stubble. By sowing the tree seeds with the oats or rye or millet, the seedlings derive a three-years' protection from the crop, and afterwards from the stubble.

No exhaustion of soil is anticipated from a three to four years' fore-farming. Reforestation by these methods has been practiced in all parts of Germany. About 5,000 acres are farmed in this manner, and about 75,000 acres of forest which originated in this way exist in the western provinces of Germany. It has been especially in vogue in Hesse ("Roederbau") for more than a century with the greatest success, as is testified by over 5,000 acres of finely grown pine, spruce, fir, and beech forest up to one hundred and twenty years old, with a yearly average accretion of 90 cubic feet per acre, a remarkable production.

Here the practice is, after a crop of potatoes, to sow pine and oak together with rye and oats; or else to plant the oak and pine, and farm between the rows, on better soils for four years, with a rotation of potato, rye, potato, rye, or for two years with potato followed by rye on poorer soils (conifer soils). By this method sometimes a surplus over and above the cost of reforestation and cultivation of \$12 to \$14 per acre was obtained.

Another method was to crop the ground with potatoes, and then

for one year between-farming with grain, trees being introduced by seed or planting.

A somewhat different management is the temporary use of a coppice for agriculture ("Hackwald," "Hauberg"). About 17,000 acres are annually so used in western Germany and probably a larger amount in France. After the coppice is cut, which is often done in early fall because the brush with the leaves on gives more ashes, the brush and soil cover is burnt over; and by piling an extra amount of brush on the stumps of undesirable kinds these are exterminated, the ashes are evenly distributed, and rye is sown and covered with the hoe. In the spring fail-places are stocked with oak, either by sowing or planting the roots (stumps).

This method may be of some use in the oak coppices which are grown for the tan-bark, as quality and value of the latter are said to be enhanced by the fertilization with ashes. It is, on the other hand, sufficiently well proved by experiments that an advantage to the forest as such does not accrue from such management; on the contrary, deterioration of forest conditions is unavoidable from the use of fire.

PARIS EXPOSITION.

In conclusion, I should mention that much time was not unprofitably consumed by the Division in preparing an exhibit for the Ohio Centennial Exposition, and again for the International Exhibition at Paris. The exhibit at the latter place, which will form the subject of a special report, may claim to be the first forestry exhibit from our country which deserved such a name, holding itself strictly to matters of forestry as an art by itself, and not attempting to make a display of the various manufactures which rely upon this art and promiscuously of the many woods, important and unimportant, which make up our forest flora. In subsection A, Forest Botany, of the four hundred and twenty or four hundred and thirty species of timber trees which are found in the United States, a selection of one hundred and twenty was made, which represent those probably of importance to forestry. These were exhibited in hand-specimens of wood blocks and botanical specimens, arranged in groups and provided with descriptive labels, so that the beholder could at once study the species in all its aspects. The labels, showing on a small map of North America the field of distribution of the species, were mostly furnished by the Museum of Natural History in New York, from the well-known Jessup Collection. Through the courtesy of the Massachusetts Society for the Promotion of Agriculture, the entire set of colored plates contained in Michaux's North American Forest Flora is exhibited.

There are also photographs showing the characteristic trees of our forest flora. To show the anatomy of our woods, microscopic sections, transverse, radial, and tangential, of twenty species were enlarged one hundred times and photographed, forming a novel and most instructive exhibit.

A collection of the seeds of one hundred species of forest trees leads the exhibits in subsection B, Forest Culture, and a neat model of the tree-planter above referred to shows the manner in which we shall presently clothe our prairies and plains with a verdant growth.

The most unique exhibit, however, is a collection of some fifty sets of sections taken from as many trees at different heights, which show

the rate of growth of the various species usually planted, from different localities of the country.

This exhibit has proved full of a large amount of information in regard to tree growth, which I regret lack of space does not allow me to dilate upon in this report, but which will form a valuable contribution for a later publication.

Other exhibits, showing the size and quality of our woods, the barks used for tanning—one mammoth piece of hemlock-bark measuring 8 by 12 feet—the methods of logging and tools used in the lumbering operations, and the many smaller items, maps, photographs, plans, etc., it would lead me too far to enumerate.

The limited space allowed for a report like this can not possibly contain a full account of the work done and the results achieved in a year's work on a field which reaches out in so many directions as that of forestry.

All I can hope to do is to show to the reader the diversity and variety of directions in which the attention of this Division is called, and to impress upon Congress and the public, as I have tried in my former report to do, the need of better facilities for doing the useful work which this Division could perform if properly endowed.

Respectfully submitted.

B. E. FERNOW,
Chief of Forestry Division.

HON. NORMAN J. COLMAN,
Secretary of Agriculture.

REPORT OF CHIEF OF SEED DIVISION.

SIR: This may be properly classed as the Primary Division of the Department of Agriculture. By act of Congress, March 3, 1839, an appropriation of $1,000 was taken from the Patent Office fund, which was then deemed a sufficient amount to appropriate "for the purpose of collecting and distributing seeds, prosecuting agricultural investigations, and procuring agricultural statistics." It was by this timely and important act of Congress that the Agricultural Division of the Patent Office was created.

The average amount expended annually during the fourteen years dating from the time the first appropriation was made until 1853, when the first annual appropriation was made from the Treasury, did not exceed $3,000. In 1854 the amount appropriated was $35,000, which has been gradually increased until now the appropriation to the Seed Division alone, for the distribution of seeds, plants, cuttings, etc., exceeds $100,000 annually.

The foundation of the world's prosperity is an abundant annual crop. A prime basis for a good crop is good seed. If we would increase the annual average crop of wheat, we must take more care in the selection of seed. The average yield per acre of the United States is about 12 bushels, while the average yield in Great Britain is 28 bushels. To add a single bushel per acre to the annual wheat yield in America increases the income of the farmers to a sum equal to about $40,000,000.

The average yield of corn per acre, according to statistical reports, is about 24 bushels. The total yield is now about 1,700,000,000 bushels a year. With a little more care in the selection of seed, and more thorough cultivation, this product can be increased one-third, which would amount to a sum so vast as to seem incredible. Other leading crops can be increased in the same proportion by the careful selection of seed and more thorough cultivation.

A recent writer tells us "that the fertility of the soil is the measure of its capability for supporting vegetable and animal life, and on this depends much of the growth and prosperity of a country." If this be so, it is a matter of vital importance that the agricultural interests of a country should be made its first consideration. The fact is beginning to be recognized that the problems which the farmer of to-day must solve are more intricate than those to be solved in any other occupation. They are as deep as the mysteries of vegetable and animal life, and their solution is a matter of such careful scientific investigation that the ordinary farmer could not use or interpret them any more than the scientist could, without practice, guide the plow and "lay the furrows straight and smooth."

One of the most important of these various problems to be solved by the agriculturists in all parts of our great country is the improve-

ment of the pastures and meadows. With the increased demand for grasses and forage plants the Department has made a special effort to meet the want, and to secure those varieties possessing the greatest merit and to distribute them in the localities apparently best adapted for their general cultivation. The distribution of Florida-grown Teosinte by the Department has proved to be a step in the right direction. The greatly increased production of this seed in Florida and in the localities contiguous to the Gulf of Mexico has reduced the price sufficiently to warrant the planting of a large acreage for forage. Heretofore the seed has been imported, and the high price at which it was held deterred many from planting. The reports received in this Division indicate its special value as a forage plant.

Judge Miller, of Bluffton, Mo., writes:

> It is one of the most remarkable forage plants of recent introduction. One single grain in a hill in good soil will produce a mass of shoots that is astonishing. Cattle and horses eat it greedily, both leaves and stalks. I made a calculation that an acre would yield 70 tons of green feed.

It will unquestionably become a paying crop, and as a forage plant has hardly an equal. But few species of noxious weeds or plants can live under its dense shade, and it completely exterminates many of them in the course of two or three years.

Kaffir corn has also been a success as a forage plant, and has flourished from Maine to Florida, and from the Atlantic to the Pacific. It is easily cured and produces uniform heads under all circumstances.

The Serredella, a fodder plant introduced by the Department from Russia, is comparatively little known, but gives promise of being of value in some localities. The Hairy Vetch (*Vicia villosa*), a native of Persia, it is thought will become a valuable addition to the forage plants in the winter-wheat-producing districts. It grows thriftily and blossoms profusely, and is therefore an excellent plant for bee pasturage.

The Alfalfa clover (Lucerne), which has been widely distributed by the Department during the past four years, is likely to be more generally cultivated than it has been heretofore.

A correspondent of the Department whose farm is in the James River Valley, Virginia, gives the following as his experience with it:

> On a field of 10 acres, that had been well cleaned the previous year, I sowed during the month of April, 1885, 25 pounds of Alfalfa to the acre. It came up quickly and kept down the weeds, making finer hay than when it is sowed too thinly. The first summer I cut it once and got about 1 ton to the acre. Last year I cut it three times and got some 4½ tons per acre. This year I have cut it already three times which will make at least 5 tons per acre, and it is about ready to cut a fourth time which will yield about 1 ton per acre. That will make in all some 6 tons per acre this season, but it must be remembered that this is grown on very rich James River bottom land. My cattle, horses, and sheep all seem to like Alfalfa, and I think it improves the land more than any other hay crop.

Some time since, a correspondent of the *Greenville Times* (Miss.) made the following statements in regard to Lespedeza, or Japan clover:

> I have seen a little patch of this clover in the midst of a large sedge-grass field gradually kill the former out and convert an otherwise useless area into a smiling meadow. Strange to say, while it kills out all other grasses, it can be easily exterminated itself. In some cases even Bermuda has been known to succumb to its rapacity. Stock fatten and keep sleek on this clover, and parties well acquainted with its merits say they get 25 per cent. more cream from the milk furnished by the

cows that graze on this grass than any other food. A qualitative analysis was made of this clover at the Agricultural College, and the result showed that it contained 72 per cent. of nutritious substances, as compared with the 51 per cent. of Northern Timothy. It is even claimed that it acts as a fertilizer, enriching the ground from which it springs. It dies down in November, and in early March is again showing its green branches.

N. W. McLain, agent of the apicultural section of the Entomological Division, stationed at Hinsdale, Ill., writes thus to the Department regarding the Chapman Honey Plant:

The *Echinops spherocephalus*, a plant native in Central France, is now, by common consent, becoming known in the United States as the Chapman Honey Plant, on account of Mr. Chapman, of Versailles, N. Y., being the first to cultivate the plant in the United States, and first to call the attention of those engaged in bee-keeping to its value as a honey-plant. The plant grows from 3 to 4 feet high, each root and stem bears from six to twelve branches, and each branch stands upright, crowned with a round ball, the entire surface of which is covered at the time of blooming with small white flowers having bluish stamens. The stalks and leaves very closely resemble those of the thistle, but the crown is aptly described by its botanical name, round-headed, and in appearance like a hedge-hog. The time of blooming is from and after July 15; the term of blooming is from eight to fourteen days, varied by the nature of the soil and the season. The term of blooming may, however, be prolonged four or five weeks by cutting back a portion of the plants. This fact is significant when estimating the value of this plant to the honey producer. This plant stands among the very first as to the quantity and quality of honey to be obtained from one source. The plant is hardy, easily propagated and perennial, and flourishes on poor or good soil, and there is no danger of it becoming a pest or noxious weed. The seed must be scattered in waste places or sown like onion seed. It does not bloom until the second season, and, as it does not spread, is easily exterminated. Frequently eight or ten bees may be seen at one time on a single crown, and by actual count 2,135 separate visits have been made by bees to a single head or crown in one day, from 5 o'clock a. m. to 7 o'clock p. m.

During the past two years the Department of Agriculture has made an earnest effort to disseminate as widely as possible such varieties of wheat and other grains as were deemed to be specially adapted to particular localities, and has received numerous reports from the growers, indicating that many of them are likely to prove very valuable. Complaint has been made that a single quart is too small an amount for trial. Nevertheless one quart of seed properly sown, broadcast or in drills, will occupy 5 square rods of ground, or a thirty-second part of an acre. From this 60 to 100 pounds of wheat can be produced. This quantity, when re-sown, ought to produce from 20 to 30 bushels, so that the entire neighborhood can be quickly supplied with it, provided it proves to be specially adapted to the locality.

It is the aim of the Department to distribute enough seed to thoroughly test each valuable variety of wheat, corn, barley, oats, or other cereal in every Congressional district in which it is probable that they can be successfully grown. The increased production per acre, and the greater weight per bushel of a superior quality that has resulted from the distribution by the Department, would, if the facts could be aggregated, convince the most skeptical of its value to the country at large. The value of the seed distribution is best evidenced by the records in the annual reports of the Department. For instance, in that of 1868 it is shown that the wheat crop reached 224,036,600 bushels; acreage, 18,460,132; average yield per acre, 12.1 bushels; value of crop, $319,195,290; average price per bushel, $1.42.

The reports of experiments with Tappahannock wheat distributed by the Department show an average yield per acre of 25 bushels; the total yield at that rate, on the acreage of 1868, would be 461,503,300

bushels, an increase of 237,466,700 bushels, which, at $1.42 per bushel, would be a money-value increase of $337,202,714. If this wheat were to take the place of other varieties, however, and should be sown as the general crop is now sown, without the special care usual in experimenting, the average yield would, of course, fall below 25 bushels; but if the average increase per acre could be raised to 15 bushels (a low estimate for the Tappahannock) the increase in bushels would be 55,380,396; in money value, $78,640,162.

Immediately after the introduction of the Fultz wheat in 1871, into nearly every county of Virginia, from forty experiments, in nearly as many counties, the lowest yield reported was 15 bushels to the acre, while the average yield was 30 bushels. The average yield of the wheat crop in Virginia in 1871 was 8 bushels per acre, and the price was $1.39 per bushel, making a total valuation $8,852,910. If the Fultz wheat had been exclusively sown, and the average yield had been but 15 bushels per acre, a gain of only 7 bushels, the resulting increase of the value of the wheat crop would have been $7,746,896, or about one-quarter enough to pay the existing State debt. As the direct result of the very general distribution of improved varieties, the increase in the average yield of wheat during the years 1878, 1879, 1880 was 2 bushels per acre. This in forty million acreage yearly would be 80,000,000 bushels increase, or a gain to the country of about $75,000,000 annually.

Wheat has ever been considered an important crop among the nations of the world, and has, in many instances, been the measure of their prosperity; our own country has been no exception to this rule. The great increase of the wheat crop of the United States is owing largely, among other causes, to the opening up of the great grain fields of the Northwest, its cash value as an export, and its adaptability to a great variety of soils. Different localities require different varieties, as it is a well-known fact that differences in soil and climate cause such changes in the character of well-known varieties as to make them vary greatly in their agricultural values. The demand for new kinds for the purpose of testing their value is constantly increasing.

It is the uniform practice of the Department not only to carefully note the results of climatic changes on well-known varieties, but to introduce those best suited to the different sections of our wide-spread territory. An examination of the results, as drawn from the reports received by this Department on the varieties distributed, proves the excellence of Sibley's New Golden, Martin's Amber, and the Good, and their adaptability to our climate and soil. These varieties have commanded attention from their earliness, the quality of their grains, and their freedom from rust.

The Fulcaster, now being spoken of with universal commendation, is a hardy and prolific wheat. It is a hybrid of two of our most celebrated, time-tested, and hardy wheats, viz, Fultz and Lancaster, as it has the straw, chaff, and peculiar eight-row head of the Fultz, with the hardiness, long berry, and beards of the Lancaster, really possessing all the good qualities of both. This wheat has a stiff white straw that will stand up well under almost any circumstances; a white bearded chaff that clings to the grain, not shattering easily; heads long and massive, filled with the large, plump, flinty, long-berry grains. It ripens from three to six days earlier than most other varieties, and the yield is said to be fully equal to the Fultz. The originator also claims for it superior milling qualities. This wheat

was originated in the Cumberland and Shenandoah Valley region, one of the finest winter-wheat sections of the United States.

The oat crop of 1868 was 254,960,800 bushels; acreage, 9,665,736; average yield per acre, 26.3 bushels; value of crop, $142,484,910; average price per bushel, 55 cents. Reports of experiments with the Excelsior oats, a new variety, introduced by the Department, show an average production of 40 bushels per acre, 60 bushels not being an uncommon yield. Estimating the average yield, if generally introduced, at 30.3 bushels, an increase of 4 bushels per acre over the average yield of 1868, and the addition to the wealth of the country in the item of oats would be 38,662,944 bushels, or $21,264,619.

The weight of the product of the Excelsior oats for a few years after their introduction may be fairly averaged at 20 per cent. above the common varieties, estimating the latter at 30 pounds to the bushel and the former at 36, although in many cases 40 and 45 pounds per measured bushel have been reported. Add 20 per cent. to the sum above ascertained, and an increase will be shown of $25,517,542.

The increase in yield of oats by the introduction of improved varieties, imported or grown in localities especially adapted to their growth, has been from 10 to 30 bushels per acre, sufficient to pay the entire cost of growing the crop, thus leaving the usual average crop one of clear gain to the producer.

The outlook for the tobacco-grower has not been materially improved since the previous report from this Division was issued.

The production of inferior and low grades of tobacco still continues; and by far too large a per cent. of the crop of 1888 is sold for less than the actual cost of production. One cause of this condition of affairs is that too little attention is given to the careful selection of seed. Maj. R. L. Ragland, who is regarded as the best authority in this country of the best method of producing what he aptly terms pedigree tobacco seed, says:

> Tobacco seed grown and saved like buckwheat, *i. e.*, every panicle on the stalk allowed to remain and bear capsules, will turn out double the quantity in yield over seed plants trimmed of all their lower branches, and only three or four at most of the top ones allowed to bear seed. The pruning process, however, is the proper mode, for by it the seed capsules are larger, the whole force of the plant is directed to the formation of fewer capsules with seeds of higher vitality, which may be more surely relied upon to transmit their peculiar good qualities. Seed thus grown is more reliable in every essential quality, and should never be classed with seed grown after the old methods.

In view of the present somewhat depressed condition of the tobacco market, the proposition to reduce the acreage, as a remedy, is by no means as feasible a one as that of a fixed and united determination on the part of the growers to plant only the choicest seed, irrespective of the price, inasmuch as the amount necessary to be expended for sufficient seed to plant a large area is relatively very small. The first step to be taken is that of procuring seed from growers in localities where it attains its highest perfection. Good seed, good soil, good cultivation, and therefore intelligent, skilled manipulation will surely result in the production of a fine staple that will always sell at remunerative prices.

In the annual report of this Division for 1887 a brief allusion was made to the recent boom in tobacco, especially in Florida. The Department, ever cognizant of the growing needs of the country, has this year given special attention to the procuring of new varieties, or those tobaccos which seem best adapted to the different tobacco-raising States.

The improvement in all varieties has been strongly marked in the last decade, and old varieties with but few exceptions are fast going out of use as better ones are being introduced.

What the tobacco-growing regions of the United States now need are better facilities for curing, with a better understanding of the best methods of handling, if tobacco is to continue to be one of the great money crops of this country. Tobacco requires early planting. Experiments made in southern Florida with Deli Sumatra and other varieties, by planting seed from January 15 to March 15, to find which months were the most suitable for tobacco planting, have proved conclusively that the earlier is the most successful. Transplanting should not be later than April 5 or 6, as later the rays of the sun become too strong, and if the crop is not harvested by the middle of August the tobacco-worm becomes so numerous as to destroy the whole crop despite the greatest care.

There is no question as to the adaptiveness of soil and climate of our Southern States to the cultivation of the finest grades of Cuba tobacco. Sumatra, Vuelta Abajo, Imported Havana, and the Persian appear to be among the choice varieties. The Sumatra and Vuelta have yielded from 800 to 1,000 pounds per acre in Florida during the past season, which yield will be largely increased when farmers become more familiar with the most approved methods of culture.

Sumatra excels as cigar-wrappers, being described as "fine as split silk, tough as whalebone," and the Vuelta is equally as fine for fillers. An interesting fact in regard to the Sumatra has been sent to the Department by Hon. Ramon O. Williams, consul-general at Havana. It is this: Messrs. H. Upman & Co., an old German tobacco house of Havana, state that twenty-five years ago they executed an order for tobacco seeds received from the Government of Holland. This seed was sown as an experiment in the island of Sumatra, and the superior leaf now produced in that island is extensively used in Europe and the United States for cigar-wrappers.

A reliable correspondent of this Department writes with regard to his experiments with the Vuelta Abajo (imported) in Copiah County, Miss., as follows:

> It proved to be as fine in flavor and size of leaf as any ever produced in the island of Cuba. Some of the leaves were taken to New Orleans and given to an expert cigar-maker, who made them up as an experiment, and they proved equal in every respect to the finest imported Havana. It was exceedingly aromatic, even when smoked in a pipe. I can affirm that from imported seed the Vuelta Abajo in central and southern Mississippi grows as luxuriantly and produces as fine a quality as that grown in Cuba.

The Department of Agriculture has not been unmindful of its duty to the American tobacco-growers, for the selection of seeds sent to every section to which they are now known to be best adapted has created an unprecedented inquiry for the Department tobacco seeds.

During the past year especial attention has been given to securing a liberal supply of such varieties of grains, grasses, and forage plants for distribution as have attracted particular notice in the localities where they are indigenous or have been originated by careful selection, hybridization, or otherwise. When properly labeled and ready for distribution they have been sent to the different localities where the soil and climatic conditions seemed to warrant their general cultivation. These efforts, judging from the flattering letters of approval that have been received, indicate the high appreciation of the

efforts of the Commissioner, which have been so promptly seconded by this Division.

The greatly increased testimony of the recipients of Department seeds during the past year is indicative of the great utility and public economy of the present distribution of seeds.

It is a fixed principle of the Department of Agriculture to push the dissemination of new varieties until they are widely enough distributed to ascertain their adaptability or non-adaptability to all localities in the United States. As soon as this is accomplished the practice is discontinued. For this reason the national distribution should, it seems to me, be of more advantage than disadvantage to the leading seedsmen throughout the United States.

The direct benefits resulting from the distribution of Department seeds, would, if aggregated, represent more millions than the seed has ever cost in thousands, in any year of its existence. Wherever a marked increase of crops has occurred the result has generally been attributed to the new and improved varieties of seed distributed. The statement is frequently made by correspondents that the seed received by them had increased the yield of crops from 10 to 50 per cent. The records of the Department teem with evidences of the money value of the increased production due to the introduction of new seeds.

Many indirect factors of great general value can also be secured by a study of results of seed distribution. The benefits obtained from a mere change of seed from one climate to another, or from one kind of soil to another, are sometimes very marked. The records of the Department show that on farms where the wheat crop, from an average of 24 bushels per acre, has gradually diminished to 20 bushels or less per acre, a change of seed again run up the crop to its former average maximum yield, thus indicating that a diminishing production is not always attributable to soil deterioration alone, and that a systematic rotation of seed exchange is a potent factor in maintaining the productive capacity of the soil.

Not the least of the benefits resulting from the introduction of new varieties of seed is the mixed and varied husbandry made possible thereby. In no Department of the General Government has the expenditure of so small a sum been productive of as much good as that expended in the introduction and dissemination of valuable seeds and plants.

Nothing can be more injurious to the agricultural interests of the nation than the wide dissemination of imperfect seed, and that which is untrue to name, either by professional seedsmen or by the Agricultural Department. It would be a great gain for American farmers, truckers, and gardeners if more seedsmen would exemplify by their practice the principle that "honest dealing is the only basis for permanent prosperity."

A prominent fact in connection with the purchase and distribution of seeds, as now conducted by the Department of Agriculture, is that it has ceased to receive old and worthless refuse seeds; for all those that will not stand the test to which they are now systematically subjected are promptly rejected. As the method of testing the seeds adopted September, 1885, is a successful one in every essential particular, it is not likely that it will be discontinued, but that the system will be still further perfected. The seed-testing apparatus now in use consists of two heavy block-tin pans, 17 inches in length by 12 in width and 2¾ in depth. These pans are painted inside and out.

Two and one-eighth inches from the bottoms of the pans a ledge half a inch in width is soldered to the sides. It is upon these that the ends of the brass rods rest which support the V-shaped pockets which reach nearly to the bottoms of the pans. The brass wires No. 9 size, are each $11\frac{3}{4}$ inches in length. To make the pockets, take two strips of unbleached thin muslin, each $10\frac{1}{2}$ by $2\frac{1}{2}$ inches, and turn a hem seven-sixteenths of an inch on each and then stitch the two pieces together $1\frac{1}{4}$ inches from the unhemmed edge. The supporting rods are passed through the hems and project half an inch beyond the ends of the pockets. The bottoms of the pans are covered to the depth of half an inch or more with water so that the lower edges of the pockets come in contact with it, and the seed is kept moist by means of capillary attraction. The seeds to be tested, numbering 25, 50, or 100, are placed within the muslin trough and moistened, and each pan is then placed near the window and each is covered with a heavy pane of plate-glass. The date the test is begun and closed is carefully noted, as well as the per cent. of the seeds that have germinated. For use on the farm, for determining the vitality of corn, grass, clover, and other seeds, any comparatively shallow pan will answer the purpose, provided the depth of the pockets is diminished, as the ends of the rods can rest on the sides of the pan and an ordinary pane of glass can be used as a cover to retain the proper degree of heat and moisture. By this method the proper degree of ventilation will be given, and the side ledges $2\frac{1}{8}$ inches from the bottom of the pan can be dispensed with. If the pan is supplied with water the plants will continue to grow, and the pockets through which the roots will have penetrated, can, after the wires are withdrawn, be subdivided with a pair of scissors and the plants be transplanted with the pieces of cloth, and their growth will thereafter be rapid and continuous if the season and the necessary conditions are at all favorable. By this method not only can the purchase of worthless seeds be obviated, but if already purchased the proper amount of grass and other seeds to sow to the acre may be definitely determined even though one-quarter or one-third of the seed possesses no vitality whatever.

It is believed by many progressive agriculturists in this country that the time has arrived for establishing what are termed seed-examination stations. These stations are needed fully as much as those for fertilizers, several of the latter of which are now doing excellent work in connection with various agricultural colleges located in States where commercial fertilizers are being generally used. The constantly increasing amount of adulteration that is being practiced, especially in grass, clover, and other field seeds, has created a pressing demand for them. The losses which annually accrue to the agriculturists from the use of poor or nearly worthless seeds are greatly underestimated, and would, if aggregated, annually amount to many hundreds of thousands of dollars. The failure to obtain a good "catch" or "stand" is almost invariably attributed to the season or other causes instead of the real one, that of too large a proportion of worthless seed. Good seed, good soil, and good cultivation are essential elements if success in farming or gardening is to be attained.

No State should be without its seed-examination station, which should, in connection with the experiment station, take up this special line of work and carry it forward. Seedsmen would be benefited, and the wise agriculturist would, when he has occasion to

purchase seed, buy only from seedsmen who are interested in the success of this enterprise, or who are willing to have the seed which is grown or handled by them impartially tested by acknowledged experts before a sale is made.

A seed-control station of this kind was established in Austria in 1880. It is now under the direct superintendence of the Agricultural Society of Vienna, and the scope of its work has been enlarged by adding to the control of seeds the additional scientific work of determining the feeding value of various feeding substances and other scientific work of similar character. The examination of seed had become a necessity on account of the increased tendency on the part of unscrupulous seedsmen and seed-growers to adulterate fresh seed with that which was old and worthless. A small per cent. of impure seeds means very many in a bushel.

As soon as the Vienna Seed Control Station began the examination and thorough test of the samples received from various growers and dealers it became apparent to the leading seedsmen that the proper course for them to pursue was to sell only such seeds as had been analyzed by the station. The seeds to be tested are numbered 1, 2, 3, 4, etc., and are forwarded by the purchaser to the station, the name of the grower or of the seedsman being withheld from the managers of the station. If the seeds have more than a certain per cent. of weed seeds, or if less than a given per cent. of the varieties tested germinate, the buyer can return the seeds to the party from whom he received them and have the purchase money refunded. Many of the most reliable seedsmen from other countries have already opened correspondence with the superintendent of the Vienna Seed Control Station.

CONDENSED REPORTS FROM CORRESPONDENTS.

ALABAMA.

Corn.—The White Giant Normandy matured early and was equal to if not superior to any that has been raised in this State. The Champion White Pearl is a general favorite.

Oats.—We need a rust-proof variety for this climate, yet the Burpee's Welcome has been successfully raised in the northern part of the State.

Wheat.—Very little wheat is raised in Alabama as it is liable to be injured by rust. The Fulcaster has proved to be one of the best varieties for general cultivation recently introduced.

Teosinte.—Grew finely and is an excellent fodder plant, and its popularity is on the increase.

Kaffir corn.—Is a drought "defier;" it is very vigorous and yields abundantly.

Tobacco.—Havana has proved a valuable variety in the southern part of the State, and in exceptional localities throughout the State.

Vegetables.—All varieties of vegetables thrive here. The time of planting varies somewhat with the season. There is a growing demand for early varieties. The best vegetables raised here are from the Department seed, which rarely if ever fail to germinate. Among the many that are especially successful are the Long Dark Blood Beet, which is particularly commended as very fine and of delicious flavor. Some of Kolb's Gem Water-melons weighed 40 pounds each.

ARKANSAS.

Corn.—The White Giant Normandy and the Champion White Pearl matured three weeks earlier than common corn, with a fine yield from both varieties. The Pride of the North is reported as being 50 per cent. better than other varieties under the same circumstances.

Cotton.—Peterkin's Improved made the best cotton, while King's Improved produced a larger yield of superior quality and resisted drought better than other varieties tried. Shines' Early Prolific is reported as being very early and productive.

Clover.—Alfalfa grew to the height of 15 inches; the dry weather continued until the last of December; after two weeks of warm weather the clover again started and grew vigorously.

Teosinte.—The foliage is abundant and it resists the drought well.

Tobacco.—The Whitt and the Orinoco are both well adapted to this section; the Orinoco more nearly resembles the products of the tobacco regions of Virginia and North Carolina than any other varieties tried in this State. The Sumatra is reported as having yielded 1,500 pounds of extra quality.

Grasses.—The Johnson was not cut until October; it reached a height of 6 feet.

Sorghum.—One-half acre planted with the Early Orange without manure or fertilizer made 99½ gallons of extra sirup. Three-fourths of the molasses made in White County this year was made from Department seed.

Vegetables.—Gardening here begins in February and March. Among the vegetables reported as giving fine results are the Improved Red Valentine Bean, Eclipse Beet, Sure Head Cabbage, Early Chavigne Lettuce, and Beaumont's Wonder Water-melon.

CALIFORNIA.

Corn.—Only the early varieties of corn mature in the northern part of California. In the southern part it yields an abundant crop. The chief grains in the northern section of the State are barley, oats, and eight-rowed corn.

Oats.—Hargett's White has been very successfully raised from seed sent out by the Department.

Kaffir Corn.—Was cut three times, notwithstanding the drought. It produced a great abundance of green fodder and a great quantity of seed. It is one of the most valuable forage plants ever introduced here, both fodder and grain.

Vegetables.—The Chino Valley *Champion* says: "Among the really good water-melons received from the Department of Agriculture is the Kolb's Gem. It is quite large, with yellow core and dark seeds. It is crisp and of delicious flavor. Ripe ones were plucked about the last of July, and a second crop was produced after that. The vines received no water and there was no rain after that which fell in the spring. Summer Marrow Squashes, on exhibition at the chamber of commerce, at San Diego, were considered the best ever produced in this section."

COLORADO.

Corn.—Pride of the North has been cultivated with great success in the southwestern part of the State, and matured earlier than other varieties tested.

Oats.—Burpee's Welcome is a very rapid grower; the heads were full. This variety is free from rust and is adapted to the southwest.

Sorghum.—The Chinese variety is well adapted to this part of the State.

Kaffir Corn.—Made a growth of about 5 feet and withstood the drought well.

Vegetables.—The Sugar Beet did very well. The larger the seed, the larger the beet. Some seeds were selected for size and produced beets that averaged 12½ pounds, a few weighing 26 pounds. The beets produced from the smaller seed planted separately weighed from 2 to 5 pounds. The Hungarian water-melons were of very superior quality.

DAKOTA.

Corn.—From 1 quart of seed of the Pride of the North were raised 8 bushels 18 pounds of good sound corn, enough to plant 25 acres this year.

Oats.—Burpee's Welcome sown in the central part of the State made a very large yield; it matures early and has full heads and plump stalk. Hargett's White also gave satisfaction.

Wheat (spring).—The White Beardless grows vigorously. The leaves are long and broad; 15 stalks are frequently developed from one grain, and each head containing 32 plump grains.

Clover.—Alfalfa grew from 12 to 18 inches in height; it did not winter-kill like other clovers. Orchard Grass is also well adapted to the soil of Dakota; it lived through the winter; both varieties appear to be just what Dakota needs.

Sorghum.—The Early Amber made a remarkable growth, measuring from 9 to 12 feet in height, and produced 1 gallon of beautiful amber-colored sirup to 8 gallons of juice.

Vegetables.—Those raised from Department seed were very fine. Some were sent to the Territorial fair at Mitchell, and after the fair were shipped to Boston, Mass., to give Dakota a boom.

The All Seasons Cabbage were very large and solid, some weighing 22 pounds. The Alaska Pea was a general favorite.

FLORIDA.

Corn.—The White Giant Normandy is very valuable for the northwestern part of the State, and proved an excellent variety for general cultivation, and is good both for field and table.

Clover.—The Alfalfa was sown in rather light sandy pine land, but did remarkably well. It is a success in this sandy country.

Teosinte.—It should be planted early in March and well fertilized. It will no doubt lead as a forage plant. Stock like it better than millet. The blades are more numerous than on corn and are both broader and larger than those of the latter. An acre of teosinte will contain as many hills as an acre of corn; two seeds may be planted in a hill and from each seed will spring from ten to twenty stalks.

Cotton.—Peterkin's Improved, even where no fertilizer was used, made 800 pounds per acre. It is an excellent variety.

Tobacco.—The reports from Florida are highly satisfactory. Sumatra leads somewhat and is represented as being a very valuable crop. Vuelta Abajo is another favorite, possessing in a marked degree the fine flavor of Cuba tobacco, and yielding from 800 to 1,000 pounds per acre. Improved Havana proved of excellent quality and large yield, the leaf when drawn through the hand having the "feel" of a kid glove. The Persian and the Cienfuegos varieties, with the exception of those named, are the most promising. A correspondent from southern Florida gives as his experience the fact that seed in this latitude may be sown at any season of the year, provided it is shaded when the sun shines very hot. If one happens to have plants ready to set out immediately after the close of the rainy season, about the time of the autumnal equinox, a good crop can be made in the fall. And he further states that he has had plants ripened and cut at Christmas.

Vegetables.—Winter and spring vegetables form two classes in this State. The early crop is increasing with the growing demand for them from the Northern States, owing to the better facilities for transportation. All vegetables grown in the United States can be cultivated here at some time during the year. Among the varieties spoken of as superior, are the Maud S. Pea; the Alaska and Fill Basket varieties; the Golden Rose and Milan Strap Leaf Turnip.

GEORGIA.

Corn.—The White Giant Normandy is a most important addition to our food crop. It is a ninety-day field corn.

Teosinte.—Produces the most remarkable growth of any plant known in this locality.

Kaffir Corn.—Is a superior grain and forage plant.

Cotton.—Cherry's Long Staple made a good crop. Its superiority consisted in its long, fine fiber, just the need of this section.

Sorghum.—The most productive sorghum for this section is the Goose Neck. It is late in maturing, but in quality and quantity is far superior to the others; the sirup resembles the West India cane. When well matured, 6 gallons of juice will make 1 of sirup.

Tobacco.—Imported Havana, Sumatra, and Vuelta Abajo are all well adapted to the southeastern part of the State, and the flavor and aroma are reported as being equal to those of the genuine Cuba.

Vegetables.—There has been much improvement in this section in gardening within ten or fifteen years, and it is without doubt largely due to the distribution of seeds from the Department. The Beaumont's Wonder Water-melon produced some fruit weighing over 50 pounds. All Seasons Cabbage gave great satisfaction, as they withstood alternate floods of rain and the extreme heat of the sun.

ILLINOIS.

Corn.—The Golden Beauty will prove a valuable crop in this section; in quality it will rank 100. The White Giant Normandy makes an immense growth.

Oats.—In the west central part of Illinois the Burpee's Welcome was cultivated with great success.

Wheat.—Sibley's New Golden stood the winter well, came out evenly and produced good grain, with stiff, erect straw. Three-fourths of an acre sown with German Emperor yielded 28 bushels of good grain.

Sorghum.—The Early Orange is reported as superior in quantity and quality to the Early Amber. A correspondent from this State writes, "5 acres of sorghum (sugar cane) will yield as much succulent feed for stock as 5 acres of beets, with not one-tenth of the labor in raising or preparation."

Tobacco.—Reports from this State are highly satisfactory. Orinoco and Sumatra germinated 95 per cent. of the seed. The yield in the southern part of the State was large and the quality excellent.

Vegetables.—The Yellow Globe Danvers Onion, the Sure Head Cabbage, the Cory Corn, the Nichols Medium Green Cucumber, the Beauty Tomato, the Rural New Yorker, the Red Valentine Bean, and the Maud S. Peas were all very productive and well worthy of cultivation.

INDIANA.

Corn.—The Champion White Pearl is one of the best varieties recently introduced. The Golden Beauty is a vigorous and productive variety. It should be planted early in the central part of the State.

Oats.—The Burpee's Welcome has a stiff straw, and the heads are both large and long. The yield was heavy and the quality superior to any grown in this vicinity.

Wheat.—Martin's Amber yielded a fine crop of nice, clean wheat. The German Emperor ripened early, stood well, and was free from rust. It is well adapted to the climate and soil of central Indiana. One quart of Sibley's New Golden produced one bushel of plump, hard grain, and the straw was stiff and straight. The Good produced fine, plump, hard grain, and is not disposed to rust.

Sorghum.—The Early Amber is a great acquisition and is considered the finest raised here.

Tobacco.—Sumatra is reported as being the finest variety ever raised in southeast Indiana.

Vegetables.—The Extra Early Six Weeks Bean and the Alaska Pea both grew luxuriantly, were large, and produced abundantly. The Osborn Beet was very fine; some measured 20 inches in circumference. The Yellow Globe Danvers Onion was of quick and large growth, and was very satisfactory. The seeds received from the Department were invariably fine, and all germinated well.

IOWA.

Corn.—The Angel of Midnight is a very early variety; it matures in ninety days; it is hardy and yielded 45 bushels to the acre. The Champion White Pearl yielded at the rate of about 80 bushels to the acre.

Wheat.—Martin's Amber is a very promising variety in the northeastern part of the State. Sibley's New Golden did very well, while all other wheats were winter-killed.

Sorghum.—The Early Amber is a great acquisition, the best variety in this part of the State. The Early Orange also does well here.

Tobacco.—The White Burley is considered a good variety, but tobacco is raised principally for home consumption. Farmers know little of the process of curing or handling.

Vegetables.—Stabler's Early Corn is a valuable acquisition. The Maud S. Pea is of excellent quality; the yield was immense. Of the tomatoes the Selected Trophy took the lead. All Seasons Cabbage is a very fine variety. The Maltese Parsnip proved to be fine and large. The Hungarian Honey Water-melon was very large and of excellent flavor.

KANSAS.

Corn.—The Pride of the North will prove a valuable field corn for Kansas, because ordinarily it will ripen before the dry season, which is at its height about August 15.

Oats.—The Burpee's Welcome yields from 95 to 100 bushels per acre, and has been known to yield 110 bushels to the acre.

Wheat.—The German Emperor yielded 42 bushels per acre; the quality was soft and fair, ranking No. 1 with millers. It requires a rich, heavy soil. The flat bottom lands of Kansas will produce from 25 to 40 bushels per acre for ten successive crops. The German Emperor stands the winter well.

Clover.—Alfalfa made a fine growth in spite of drought, and it is a valuable forage plant for Kansas. Alsike does remarkably well in northwestern Kansas.

Kaffir Corn makes an abundance of fine feed. Hogs and cattle both eat it clean, stalks and all. When it is from 2 to 3 feet high, by cutting it close to the ground it will stool out like cane and produce from 4 to 7 shoots.

Grass.—The English Blue-Grass did finely for grazing; it stands the winter well and makes a fine lawn grass.

Sorghum.—The Orange yielded 130 gallons of the best quality of sirup to the acre. The Chinese Cane yielded well, and the sirup was preferred by some to that made from other varieties. The sirup received first premium at the county fair.

Vegetables.—The Hackensack Musk-melon was the best of five varieties. The Olive-Shaped Radish was crisp and delicious. The Maud S., Harrison Glory, and the Alaska Peas proved to be most desirable acquisitions; too much can not be said in their favor. The Odella Water-melon yielded two crops; many of them weighed 40 to 50 pounds each.

KENTUCKY.

Oats.—The Burpee's Welcome do very well in Kentucky.

Wheat.—The Good is a superior variety: it is clear of rust and stands up well; produces a large-sized, well-developed grain.

Sorghum.—The Chinese Cane is an excellent variety, and although planted late it reached the enormous height of 15 and 16 feet. It was used entirely for feeding stock.

Vegetables.—The Alaska was very fine and particularly free from the obnoxious bugs that too often infest the pea. The Sutton Gem Lettuce was a great success; the Olive-Shaped Radish made an extra yield, being very crisp and fine.

LOUISIANA.

Cotton.—Jeff Welborn's Pet is an excellent variety, fruits well, and matures thirty days earlier than most of the varieties grown here.

Tobacco.—The White Burley has been raised successfully, having yielded 1,000 pounds to the acre. Much more attention is given to cotton than to tobacco, but it is thought much more will be given to the culture of tobacco next year.

Vegetables.—Garden vegetables are usually planted during February and March. The finest vegetables raised this season were from seed obtained from the Department of Agriculture. The varieties were: Case-Knife Beans, Sure Head Cabbage, Early Blood Turnip Beet, and Early Trophy Tomato.

MAINE.

Oats.—Hargett's White is reported as the best grown in this section. The stalks attained a height of 5 feet 3 inches. The grain before thrashing weighed 150 pounds. The net weight of the thrashed grain, 41½ pounds. This was the product of 50 stalks.

Kaffir Corn.—Is considered the best for fodder of any tried in this State.

Vegetables.—The Royal Dwarf Cranberry Bean, Burbridge's Eclipse Pea, and the Danvers Silver-Skin Onion produced well and were of fine quality. The Victoria Lettuce lasted three months.

MARYLAND.

Corn.—The Golden Beauty is considered to be well adapted for general cultivation. The White Giant Normandy proved very vigorous.

Oats.—Hargett's White are No. 1 in quantity and quality.

Wheat.—From 1 quart of Sibley's New Golden seed the yield was 79 pounds of clean wheat. The straw is stiff and is entirely free from rust. The grain is large, prime in quality, and of a clear amber color. The Good was very successful in northern Maryland. It is reported as being very satisfactory and the earliest variety yet tested.

Tobacco.—The White Stem Orinoco made a large yield of fine and silky quality. The Deli Sumatra is raised here to perfection. Isabella cures nicely and has an exceedingly pleasant odor.

Vegetables.—The Maud S. Peas were No. 1 in quality, with good yield. The Giant Onions were very fine; the Eclipse Beet grew large and was early and tender. The Early Red Valentine Bean, the All Seasons Cabbage, and Long blood Beet were all excellent varieties.

MICHIGAN.

Corn.—The Eight-Rowed Canada yielded 90 bushels to the acre in the southeastern part of the State.

Oats.—Hargett's White is the earliest variety in this section. The berry is very plump, the straw stands up well, and yields at the rate of 62½ bushels clean oats to the acre.

Wheat.—The German Emperor proved to be of good quality, the straw being stiff and free from rust, and the grain was plump and of No. 1 quality.

Clover.—Alfalfa does well here.

Grass.—The English Blue Grass made a very fine growth for the first year's planting.

Vegetables.—The Sure Head Cabbage weighed from 25 to 30 pounds. The Alaska Pea yielded thirty times the amount of the seed planted, and is a choice variety. The Eclipse Beet is one of the best for northwest Michigan. The season in the northern part of the State is short, but vegetables mature quickly.

MINNESOTA.

Corn.—The Angel of Midnight yielded well and is regarded as being a very desirable sort.

Wheat.—The German Emperor in the southern part of the State has given satisfaction. The straw was strong and stiff, did not rust, and the quality of the grain was good.

Vegetables.—At the county fair at Glenwood the display of vegetables was equal to any shown in the State, a large part of which was raised from Department seed. The Snowball Turnips exhibited were very early, vigorous, and excellent. The Nichols Medium Green Cucumber proved to be one of the best varieties grown here. The Alaska Pea was very sweet, and had a large number of peas in the pod.

MISSISSIPPI.

Corn.—The White Giant Normandy is a favorite stock corn in this State. It is very early, and for this reason very valuable in dry seasons.

Teosinte.—Affords a wonderful amount of foliage and can be cut twice during the season in this locality.

Kaffir Corn.—Made a fine growth; it has proved a fine success and will be a benefit to the community.

Cotton.—The Maxey is the heaviest cropper we have in this section, notwithstanding it has a medium boll, but it is long-limbed, fruits close, and has small seed. The Taylor made 2,740 pounds per acre, without fertilizers.

Tobacco.—Spanish Hybrid and Orinoco are perfectly at home in southeastern Mississippi. Tobacco would pay as well here as cotton if there were experienced laborers and manufacturers.

Vegetables.—Tailby's Hybrid Cucumber is well adapted to this section (northeast); its yield was simply enormous, and its quality can not be excelled. The Early Red Valentine Bean was ten days earlier than other varieties, the yield being very abundant and the quality very good. The Milan Strap Leaf and the Purple Top Munich Turnips grew to an immense size.

MISSOURI.

Corn.—The White Giant Normandy produced splendid corn, well worthy of distribution. The Pride of the North ripened in ninety days, and is a good variety.

Oats.—Hargett's White yielded well and the grains were as large again as those originally planted.

Wheat.—The Good yielded well and the grain was of excellent quality. Martin's Amber also did well.

Sorghum.—The Early Amber is considered the best variety for this locality, both in quality and quantity. The Orange also yielded well.

Tobacco.—The Spanish Hybrid and Deli Sumatra are both well adapted to this locality. The Imported Havana yielded at the rate of 1,000 or 1,200 pounds to the acre. The White Burley and White Stem Orinoco also made good yields and were of fine quality.

Vegetables.—The Victoria Lettuce was very fine, very tender, and sweet; the Sure Head Cabbage was greatly in advance of other varieties planted by their side. The

Alaska Pea made an excellent crop. The Golden Sweet Corn took the first premium at the Linn County Fair. All the seed sent by the Department has been highly prized here.

NEBRASKA.

Corn.—The Eight-Rowed Canada did well; developed a well-filled ear. The Champion White Pearl was remarkably early and proved a good corn for a general crop in northern Nebraska. The Pride of the North supplies a great need in Nebraska.

Oats.—The Burpee's Welcome is the best variety ever introduced into this country. It ripened fully a week earlier than the common white.

Clover.—The Mammoth Clover did finely; it made a good stand, notwithstanding the drought. It made a good crop of hay, being cut when it was 2 feet in height.

Grass.—The English Blue Grass germinated well, made a good growth, and stood the drought well.

Sorghum.—The Early Orange grew well, and reached the height of 8 to 12 feet; it is reported as having yielded more juice than any other variety worked at the mills this season. It is no trouble to raise here, as it will grow on any soil that will grow corn. The Early Amber made a great success in this State. The Chinese made a superior sirup.

Vegetables.—This is a fine country for vegetables. The Early Snowball Turnip, Imperial Sugar Beet, Dutch Case-Knife Bean, Maud S. Peas, Cory Corn, and Early Red Valentine Bean appear to be among the choice varieties.

NEW HAMPSHIRE.

Oats.—Hargett's White is very hardy, and yield and quality unexcelled.

Grasses.—The most desirable grasses are Timothy, Clover, Red-Top, and Orchard.

Vegetables.—Tailby's Hybrid Cucumber was an excellent variety. The Early Red Valentine Beans were unsurpassed, and were sweet and tender. The Patty Pan Squash was a very prolific variety and of excellent quality. The Rural New Yorker Pea did very well, and was a week in advance of other varieties.

NEW JERSEY.

Clover.—The Egyptian produces a somewhat larger yield to the acre than the common clover; there is no doubt that it will stand our winters. If this clover grows to the height of 3 or 4 feet in Egypt it must be because the climate is more suitable. It was something of a disappointment not to get something nearer to what is grown on the banks of the Nile.

Vegetables.—The Sure Head Cabbage grew well. The Cory corn proved very satisfactory, being very large and free from worms. The Egyptian Sweet Corn was very sweet and prolific.

NEW YORK.

Corn.—The Eight-Rowed Canada is well adapted to the east central part of the State.

Oats.—The Welcome is a very plump variety and was earlier than any other. Hargett's White proved to be a very fine sort. One root had 4 stalks, the aggregate number of grains being over 100. They outyield the Welcome.

Wheat.—The Oswego Falls Agricultural Society awarded first premium to Martin's Amber. From 1 bushel sown on an acre of land were harvested 30 bushels of full, good-sized, plump grains of beautiful color.

Vegetables.—The Livingston Beauty Tomato is all that the originator claims for it. The plants were large and strong and loaded with much-prized fruit. The Alaska Pea was pronounced as unsurpassed in quality. The Harrison's Glory Pea is also a prolific bearer and of superior quality. The Deacon Lettuce made a good yield and was of excellent quality.

NORTH CAROLINA.

Wheat.—The Fulcaster is well spoken of in the reports from this State. It is entirely free from rust and the quality of the grain is good.

Cotton.—The Cherry's Long Staple has linted and fruited well. Shine's Early Prolific and the S. B. Maxey have given satisfaction.

Vegetables.—The Extra Early Red Valentine and the Improved Valentine Beans are among the earliest, yield abundantly, and are of extra fine quality. The Maud S. and Fill Basket Peas are early, hardy, yield well, and are of superior quality.

OHIO.

Corn.—The Champion White Pearl produced fine ears and will, when it becomes acclimated, be a valuable variety.

Wheat.—Sibley's New Golden took the first premium at the Hamilton "Harvest Home" Fair, in competition with the Fultz, Martin's Amber, Longberry, and many others. The Rice has proven a valuable variety in northern Ohio. The Fulcaster is also reported as not being liable to winter-kill. It is excellent for milling purposes and is a general favorite.

Sorghum.—The Early Orange made a fine growth; it was tall, had a thrifty, strong cane, and will produce 160 gallons to the acre.

Tobacco.—The White Burley grown in the central portion of the State; the Whitt in the southwestern, and the Vuelta Abajo are grown with success.

Vegetables.—The yield of the Extra Red Valentine Bean was simply immense. It matured quite early, and was of good quality. The Egyptian Turnip Beet proved a great success. It yielded well, grew large, and took first premium at the Miami County Fair.

OREGON.

Corn.—The Pride of the North is better adapted to this soil and climate than any variety tested. It ripened six weeks before others, and the ears were very fine and large, with perfect grains.

Oats.—Hargett's White made a large yield of good quality.

Clover.—Alfalfa is the most promising forage in this locality. One crop of about one-half ton to the acre was cut and a second crop raised. The Mammoth is also well adapted to this climate; it grew to the height of about 4½ feet on river-bottom land.

Kaffir Corn.—Grows well in northern Oregon and will ripen seed. It will make a larger yield of fodder than common varieties of corn.

Grass.—The Tall Fescue (*Festuca elatior*) remained green throughout the year. Rescue (*Bromus schraderi*) grew well, seeded well, and will prove valuable if perennial.

Tobacco.—The Vuelta Abajo yielded about 1,000 pounds to the acre, and the quality was good. The climate and soil of Oregon seem well suited to the cultivation of tobacco.

Vegetables.—The Sure Head Cabbage, Snow-ball Turnip, Sutton's Gem Lettuce, Early Scarlet Globe Radish, Extra Early Six-Weeks' Bean are all reported as having given entire satisfaction. The Drum-head Cabbages grew to be of fine size, having solid heads, some of them weighing 40 pounds each.

PENNSYLVANIA.

Oats.—Hargett's White were the earliest and of better quality, and yielded more to the acre than any raised in east central Pennsylvania.

Wheat.—One and a half pints of Sibley's New Golden produced 44 sheaves, which thrashed 2¼ bushels of beautiful wheat. The seed was received from the Department. The German Emperor did very well and is entirely free from rust. It is the wheat for central Pennsylvania and can not be excelled. It withstood the winter well, while some other varieties were killed.

Grass.—Tall Fescue (*Festuca elatior*) reached a height of 10 inches and made an abundant crop.

Tobacco.—The Imported and State Havana are well adapted to this soil. Havana yields 1,500 to 1,800 pounds per acre. Lancaster County, southeast Pennsylvania, is the garden county for tobacco; from 1,000,000 to 1,500,000 pounds are grown yearly.

Vegetables.—The Bloomsdale Spinach is reported as the finest ever grown in this section. Kolb's Gem Water-melon was very fine. The Long Scarlet Short-Top Radish, Orange Cream Pumpkin, Fill Basket Pea, and the Beauty Tomato, with many other varieties, were very satisfactory in both yield and quality.

SOUTH CAROLINA.

Cotton.—Jower's Improved is well adapted to this climate.

Teosinte.—Grows luxuriantly; stools or bunches 6 feet in height and 3 feet across are common. When cut green, stock of all kinds are very fond of it. On very rich soil 50 canes can be grown from one seed.

Kaffir Corn.—Stands drought remarkably well. It reached a height of 4 feet. The heads are 10 inches in length. It will mature a second crop in this latitude. It is fully equal to corn as a forage plant, and all kinds of stock eat it greedily. One acre of Kaffir is considered equal to 2 of corn (maize) for feeding.

Vegetables.—Vegetable seed received from the Department has given general satisfaction, and is much sought after. With but few exceptions all vegetables attain a high degree of excellence here.

TENNESSEE.

Corn.—White Giant Normandy has been fully tested and is pronounced unexcelled as an early corn for this latitude, coming in before the July drought. It is a pure white corn, as its name indicates, and makes the finest quality of meal, and is soft enough for stock.

Wheat.—The Fulcaster is reported as producing the finest grain, and as being the most prolific variety grown in central Tennessee. The seed sown in the fall of 1887 yielded 35 bushels per acre.

Clover.—Alfalfa grew well; it was over 1½ feet high; it branched out until it had 5 or 6 stalks from one seed; the roots extended from 1 to 2 feet in the ground. It is one of the best that has been tried, and is just what this country needs.

Cotton.—Shine's Early Prolific is of superior quality, with very fine, long staple.

Vegetables.—The Dutch Case-Knife beans were very prolific; they are a good market variety. The Rural New Yorker Pea proved a remarkable variety, both as to quality and quantity. The All Seasons Cabbage was of good quality and made large, solid heads. The Yellow Globe Danvers Onion proved to be a very fine variety.

TEXAS.

Corn.—The White Giant Normandy and Champion White Pearl are both very excellent varieties for culture in this State.

Wheat.—The Fulcaster appears to be the best variety for this portion of our country.

Cotton.—The Jones Prolific received from the Department of Agriculture has done so well here that some planters are using it for their entire crop.

Kaffir corn.—Is the best forage plant grown here and it appears to defy summer drought. It grows uniform heads under all circumstances and is easily cured. After two years' experience with it, it is pronounced the finest forage plant ever tried in this locality.

Grass.—The Johnson is all that could be asked for. The *Erugrostis Abyssinica* grows very fast, and makes an abundance of seed. Stock are very fond of it.

Sorghum.—The Early Amber is very fine for forage. By cutting early two crops can be secured. Other varieties are preferred for sirup, but for forage nothing is superior to it. It grows luxuriantly without work, but the "better the culture" the better the yield.

Tobacco.—This soil and climate are well adapted to the cultivation of tobacco. It cures well here in mid-winter without firing. The Whitt took the lead of three varieties in central Texas; it is a strong plant with long leaves; it grows quicker and will stand more drought and wet than the others. The Vuelta Abajo resembles very closely the flavor of the Cuban.

Vegetables.—All varieties of vegetables do well here when properly cultivated. The seed sent out by the Department has proved no exception; the reports upon the distribution of the various kinds are highly satisfactory.

UTAH.

Tobacco.—The Orinoco made a good crop but needed much irrigation; it lacks the body of the Kentucky and Virginia tobaccos and is coarser in fiber than in the timber lands of the tobacco States, and yet with proper fertilizers, judicious irrigation, and experienced cutting and curing it is thought by experienced tobacco-growers that

the yield and quality would be sufficient to make tobacco one of the leading, if not the best agricultural product of the Territory, in valleys not exceeding 4,500 feet in altitude.

Vegetables.—The Early Red Valentine Bean was very much liked. The Patty Pan Squash is spoken of as a delicious and prolific variety, some plants yielding fifteen full-grown specimens. The valley of the Weber is particularly adapted to all vegetables and small fruits. It is a little over 4,000 feet above the sea-level.

VIRGINIA.

Corn.—The White Giant Normandy proved equal to any cultivated in this State, with the advantage of a small cob, which is a great consideration.

Wheat.—The Lancaster, German Emperor, and Fultz are the standard varieties. Sibley's New Golden produced grain of good quality and color; it was perfectly free from rust; the Good produced well, the straw was stiff and strong and not inclined to rust. The grain was large and plump and of a rich amber color. The Fulcaster is reported as being free from rust and one of the most promising new varieties.

Sorghum.—The Orange made a good yield. At the mill it was pronounced equal in quality to any they had used, and was superior in yield.

Tobacco.—Caboni is considered the best of the Spanish varieties; it grows large, is of a fine texture, and cures a nice color. There is a growing demand for the Little Orinoco as the product from it is unexcelled even by the Burley; it combines more good qualities than any native variety. The Persian ripens early and is of fine quality, especially suitable to localities subject to early frost. In corroboration of this, Maj. R. Ragland, who is regarded as authority on tobacco matters, says: "Of sixteen varieties planted this year on Hyco Seed Farm, the Persian is the most forward and has made the greatest growth through the driest season experienced for many years. It has stood the heat like a salamander, and made greater growth than any other variety on the farm. The Persian promises to be a first-class cigar variety, and is superior to older kinds. It is worthy of extensive planting, east and west, wherever the cigar type is grown."

Vegetables.—Sutton's Gem Celery proved a good variety, nutty, crisp, and of fine flavor.

WASHINGTON.

Corn.—The White Giant Normandy is very productive; yielded twice as much of either grain or fodder as common corn. It is a very valuable variety for fodder. Forage is much needed in this part of the country.

Wheat.—One and a half pounds of Beardless White, planted in 12 rows 50 feet in length and 16 inches apart, yielded 198 pounds of the choicest wheat.

Tobacco.—Caboni, Vuelta Abajo, and White Burley have been successfully grown here.

Vegetables.—All the varieties of vegetables and grain received from the Department grew finely here.

WEST VIRGINIA.

Wheat.—The Fulcaster yielded 30 bushels to the acre, weighing 66 pounds per bushel, of large, plump, grains. It ripened eight days before other varieties, and it was entirely free from rust.

Sorghum.—The Early Orange is well adapted to this locality.

Tobacco.—The Orinoco is best adapted to this locality for several reasons: First, because it can be planted closer and cultivated with more ease than larger kinds; second, because it ripens earlier; and, third, because there is no danger of its being nipped by frost.

WISCONSIN.

Oats.—Hargett's White were very good, and the straw was stiff and strong.

Clover.—Alfalfa made a fine growth.

Grass.—The Tall Fescue (*Festuca elatior*) did very well, and made a fine growth.

Sorghum.—Owing to a very cold spring and summer the Chinese did not mature, but the yield from green cane was tremendous—50 per cent. greater than from Early Amber.

Tobacco.—Havana is the best variety for this section of country. It is small for the first year, but the third year it pays well, as it yields from 800 to 1,000 pounds per acre.

Vegetables.—The Early Snowball Turnips did well; they yielded five times as much as some seed purchased here, which was sown on the same land with equal care.

In conclusion, I herewith append the following tabulated statement, showing the quantity and kind of seeds issued from the Seed Division of the Agricultural Department, under the general appropriation act of Congress, from July 1, 1887, to June 30, 1888:

Description of seeds.	Varieties.	Senators, Representatives, and Delegates in Congress.	Statistical correspondents.	State correspondents.	Miscellaneous applicants.	Experiment stations and agricultural colleges.	Agricultural societies.	Grand total.
MISCELLANEOUS.		*Packages.*	*Packages.*	*Packages.*	*Packages.*	*Packages.*	*Packages.*	*Packages.*
Vegetable	158	2,941,388	172,640	40,800	458,300	7,418	21,472	3,642,018
Flower	76	268,044	30,090	21,045	63,928	339	....	383,446
Chapman Honey Plant	1	....	148	....	1,416	70	182	1,816
Tobacco	15	89,107	2,925	18,325	10,841	827	1,452	123,477
Tree	7	486	....	....	2,529	44	....	3,059
Sunflower	1	....	....	....	1,525	604	....	2,129
Pyrethrum	1	....	....	....	17	17	....	34
FIELD SEEDS.								
Wheat	5	354	....	....	1,843	245	524	2,966
Oats	2	2,098	214	....	863	117	341	3,633
Corn	7	3,943	1,509	1,118	3,869	178	646	11,263
Ensilage corn	1	....	84	....	117	234	361	796
Flour corn	1	....	79	....	243	52	....	374
Sorghum	4	2,750	1,509	....	2,478	137	964	7,838
Kaffir corn	1	....	267	....	790	62	245	1,364
Broom corn	1	....	....	....	152	23	....	175
Turnip	12	253,739	105,040	27,620	19,413	2,438	23,247	431,497
Sugar beet	3	2,992	1,509	....	1,015	8	....	5,524
Mangel-wurzel	2	....	378	....	1,021	....	....	1,399
Grass	8	9,679	124	1,118	3,998	68	569	15,556
Clover	6	430	530	1,118	1,855	276	739	4,948
Millet	1	26	....	....	275	91	....	392
Teosinte	1	....	294	....	1,451	226	1,215	3,186
Forage plants, imported	4	....	143	....	1,226	184	857	2,410
TEXTILE.								
Cotton	6	4,023	....	....	1,709	95	392	6,219
Grand total	......	3,579,059	317,483	111,144	580,874	13,753	53,206	4,655,519

WM. M. KING,
Chief of Seed Division.

HON. NORMAN J. COLMAN,
Commissioner.

REPORT ON TRUCK FARMING.

TRUCK FARMING—ITS APPLICATION TO THE WORK OF THE GENERAL FARMER.

By James K. Reeve, *Franklin, Ohio.*

So long as land remained plentiful and cheap, even near the most populous centers, and the population of those centers was not so great but that it could be easily supplied with food from the adjacent agricultural districts, there was little incentive in this country for the study of methods tending to increase the productiveness of the soil. Even after the cities between the Atlantic and the Mississippi began to attain such proportions that their daily supplies had to be drawn from a constantly widening field, the owners of land in the older communities felt no particular necessity for puting forth greater efforts, because they were being well recompensed for their time and labor by the rapidly increasing value of their farms. Up to a certain point such reasoning, although fallacious to the best interest of individual owners, was certainly beneficial to the development of the country at large, as it added stimulus to immigration, and aided the constant and rapid opening up of our great agricultural territory in the West.

We are now, however, rapidly nearing a point, if, indeed, it is not already attained, where the owner of a farm in the Eastern middle or central Western States can not reasonably expect much profit to accrue from a further increase of values. The continuing growth of population will undoubtedly cause them still to augment somewhat, but not with the rapidity that the past generation has known. Applying business principles to the consideration of this question, we can not expect the value of cultivated lands to greatly exceed that point upon which a fair interest may be had from the profits of cultivation; so that men who now purchase, or those who inherit these lands that have made their fathers wealthy by a rise in values, even though the crops produced yielded only a comfortable sustenance, must look for their profit in such an advanced system of agriculture as will produce a larger money return per acre. This profit will come in two ways, the gain in income and the increase in value of the land, when it is shown that the capital invested is yielding a higher rate of interest than formerly.

Seven years ago a writer in one of our magazines* suggested that the tendency in his State (New York) "was toward the market garden, the orchard, plant-house, dairy, and small farm. The

*See "Agricultural Experiment Stations," Scribner's Monthly, February, 1881. Scribner & Co., New York.

large wheat-grower and grazier have gone to the far West." The development of this idea in the subdivision of our larger farms and the application of intensive methods, so that each cultivated acre will be made to yield the greatest possible money product, are the natural ends toward which we are now tending. The fact that in this way a smaller capital can be successfully employed than could be in cultivating larger areas for grass and grain and stock is one of the strongest arguments in its favor. The time has not yet come, nor is it desirable that it soon should, when all farmers in the great eastern and middle sections to whom this article is particularly addressed will devote themselves wholly to the various branches of "small farming," and divide their holdings so minutely as would be required to make such the exclusive industry.

A great many who hold medium-sized farms, say ranging from 100 to 200 acres, find it now impossible to continue cultivating them after the old methods, and realize, in addition to taxes and current expenses, a sum equal to a fair interest upon the capital invested. It is incumbent upon such to adopt methods that will materially increase the income, as in the majority of cases the fixed charges for maintenance can not be greatly reduced. To this class we can hardly suggest so radical a change as applying the principles of "small farming" to their entire holdings. The labor and expense necessary to so minutely cultivate each acre would in most cases be an insuperable obstacle; but it may be practicable for such to devote a limited space to the cultivation of certain crops of higher value, or to make such an adjustment of methods as would reduce the labor upon the larger portion of the farm to a minimum, and then concentrate the greatest effort upon a comparatively small area.

Before passing to a consideration of the ways in which this may be accomplished, and of the means best adapted for the attainment of the desired result, let us glance for a moment at the existing conditions of agriculture generally throughout the United States.

The report of the Commissioner of Agriculture for 1886 shows that the total area cultivated for 1885, in the following crops, viz, corn, wheat, oats, rye, buckwheat, barley, hay, potatoes, tobacco, and cotton, yielded an average gross return of only \$9.75 per acre. The only crops yielding an average of more than \$10 per acre were, cotton, \$14.75; barley, \$12.04; potatoes, \$34.49; and tobacco, \$57.49. Of these cotton is confined definitely to a certain section; tobacco and potatoes must be classed as crops of limited cultivation, leaving barley as the only general field crop giving a gross product averaging more than \$10 in value. With these figures before us it seems hardly necessary to emphasize the assertion that there can be little profit in farming high-priced lands for such results. In "mixed farming," *i. e.*, the feeding of stock in connection with the production of grass and the cereals, it is generally maintained that the net profit is somewhat better than when these crops are alone the product and are sold directly from the land instead of being fed upon it.

Even in these most common practices of husbandry our methods will certainly bear amending. In comparison with ourselves the British farmer raises on the same area double the amount of wheat, oats, barley, or potatoes, and in proportion to acreage will produce and feed much more than double the amount of live stock.

While we are not yet ready for the methods that have been forced upon the agriculturists in the overcrowded districts of Europe, where land is dear and labor cheap, and where the ratio of non-producer to

producer is so much greater than here, yet the above figures show that results, which, if attained on low-priced lands in the newly-developed West, might be very satisfactory, are quite the reverse under the conditions existing in the older-settled communities.

One of the first features requiring attention in a discussion of the economic principles of intensive farming is that of labor. This factor alone may determine the question of profit or loss in any system of agriculture, and its employment and distribution in such manner as to accomplish the best results will always demand the most careful consideration. Under our present methods we are usually working under high pressure a portion of the season, and that often, as in hay and grain harvest, when both men and teams are least able to endure severe toil, and often in the autumn and winter, when active labor would be beneficial, we find hardly enough to do on our farms to keep up even a pretense of work. The arrangement of the year's work to cover as equally as may be each season, thus affording means by which employed labor may yield a profitable return each day, is the only way in which the maximum benefit can be obtained. This can only be accomplished by growing such a succession of crops that the planting, cultivation, harvesting, and future handling of them may afford as nearly as possible a continuous round of duties.

I have already suggested that the allotment of the land should be such that the larger portion would demand comparatively little close or detailed labor. Generally speaking, this may be most readily attained by growing less grain and more grass. A second and not less important result of this procedure would be that a greater amount of stock could be kept, and a larger quantity of manure accumulated to use upon the cultivated portion. Grass lands will undoubtedly yield, in the older sections of the country, a better average net profit than would the same acreage of grain. In addition to raising cattle for market purposes, the production of milk and butter can be made a source of no small gain, depending somewhat of course on location and nearness or accessibility to markets. It is not within the scope of this article, however, to attempt any directions for the general management of the farm. The most that can be done is to offer a few suggestions, leaving each farmer to determine for himself upon such plans as may be best adapted to his circumstances and as seem most likely to meet the requirements of the desired end. Some may consider it best to put so much of the land as possible in a single grain crop, requiring only the operations of seeding and harvesting; others, by renting a portion of their fields to be cultivated for a share of the crops; others, by following mainly in the old lines, and devoting only a small area and surplus time and labor to the production of new, and to them experimental, crops. The general procedure, however, should be determined upon with a definite view of the direction in which the other work is to be undertaken.

The two principal methods open to the farmer for the profitable application of the principles of intensive farming are the production of special field crops, cultivable in limited areas and yielding a large money value per acre, and in market gardening. The former of these is applicable to the vast majority of farmers, whatever their location, as the crops I shall suggest may be harvested at a single operation and immediately shipped to the nearest large market and sold in their entirety as easily as wheat or corn. The latter is especially adapted to farmers located near cities or in the vicinity of thriving towns or villages, even though quite small, where a fair

portion of the population consists of the non-producing class. Indeed, in such places the market will often be found much better than in large cities. Although occasionally both of the above methods may be advantageously combined, I will discuss them separately, first giving attention to the cultivation of the more valuable field crops.

The statistics previously given show that two crops already somewhat extensively cultivated give very satisfactory returns. These are, tobacco $57.49, and potatoes $34.49 per acre; and we would further note that the value of these products varies for tobacco from $152 in New York down to $49 in Arkansas, and for potatoes from $80 in Florida down to $29.58 in Michigan. It is true that some of this variation may be accounted for by climatic conditions; adaptability or non-adaptability of the product to the soil or latitude; special value of certain varieties of the product which may be adapted to one locality and not to another. Yet the figures are suggestive of what may be accomplished under favorable conditions with proper care and management. For instance, in Kentucky, in the year for which the figures are given, the writer was shown a 20-acre field of tobacco from which the product sold for $4,200, while the average value of the yield for that State was only $51.35.

In addition to the above named, the specially valuable crops whose limited cultivation may generally be profitably undertaken by the farmer are cabbage, beans, and sweet potatoes. There are many others that may be successful within certain territorial limits, but those named are adapted to the widest range.

THE POTATO.

The great value of this tuber as a staple food crop, its present extensive importation, and its growing employment in manufactures are all suggestive of the fact that its cultivation might be greatly extended without danger of overproduction, and without extending its area a vast improvement can be made in the method of cultivating so as to render its present acreage much more profitable than they now are. The present low average yield is directly attributable to the fact that a moderate crop may be secured even with the most inadequate culture, and as usually grown by farmers only for home consumption, they often devote only such time and space to it as can not profitably be employed for anything else. The very ease with which some return may be had has been the greatest drawback to a thorough study of the plant and its needs. In this connection may be mentioned the fact that this facility of production was at one time conducive to serious social complications. The Encyclopædia Britannica says:

> In Ireland and the highlands of Scotland the people, already in a painfully degraded condition and contented to exist with potatoes as their sole food from year's end to year's end, took occasion, from its very productiveness under the rudest culture, to subdivide their lands and marry prematurely, with reckless improvidence and amid ever-deepening degradation.

From this condition the people were rudely awakened by the appearance of the memorable "potato disease" that at one time threatened the total extinction of this tuber from British agriculture, and occasioned such alarm in this country that in 1845 the legislature of Massachusetts passed an act offering a reward of $10,000 to any person who should discover its cause and cure.

Although, as above noted, some sort of crop may usually be made, even with the application of the slightest degree of effort and intelligence, the best success in potato culture can only be had by a thorough understanding of its needs and by carefully ministering to them. As the tubers contain nearly 75 per cent. of water it is essential that the preparation of the soil should be such as will best conduce to the retention of moisture; and as the sets do not throw out roots to feed in the surface soil, but draw their nourishment from a considerable depth, it is quite as needful that the preparation of the seed-bed should be deep as well as thorough.

Although all root crops are partial to a deep, mellow loam, experience has shown that a clay soil will produce smoother and more uniform potatoes than any other. On a loose, light soil the market value of a crop is often seriously injured by unsightly, wart-like excrescences upon the tubers; and if a clay soil be sufficiently rich and properly fitted to the requisite depth it may be relied on to produce a crop as large in volume as any other. It is not enough that the ground be merely plowed deep and then well harrowed; but after this is done commence again at the beginning and turn this fine surface under to a depth of 6 inches, placing it where the sets will be in immediate contact with it when planted. Then again harrow the new surface and mark out furrows 6 inches deep and 3 feet apart. Into these furrows drop the sets, 15 inches apart, and cover with 4 inches of mellow earth.

Upon no single point of agriculture has there been more recent discussion than regarding the best method of preparing the seed. The planting of whole potatoes, large and small; cutting lengthwise and across; cutting to two eyes and to only one; all have their ardent adherents. Doubtless good results have been and occasionally may be attained by each of these methods. To intelligently determine which is best, it is necessary to understand what purpose the seed piece is to serve. Various experiments have determined that the greatest yield of marketable tubers to the hill does not result from a multiplicity of vines. At a recent exhibition of the French Agricultural Society the premium both for size of tubers and yield per hectare was awarded to a grower whose only peculiarity of method was that he pruned away all in excess of two vines to each hill as soon as they appeared above ground. Admitting, then, that a redundancy of vine is not desired, we should aim to plant enough seed to produce the requisite amount and as little in excess as possible. This may be attained by planting a single eye, provided that one is strong, has a sufficient amount of the body of the tuber with it, and is placed in good soil where plenty of plant food is immediately available. But as all of these conditions may not be always present, the better method is to plant two good strong eyes. All more than this is "wasteful and ridiculous excess." As the seed piece must furnish nourishment to the young plantlet until it is sufficiently developed to draw its sustenance from the soil, the tuber should be so cut that a uniform amount of flesh is apportioned to each eye, and in cutting the knife should be run as deep under the eye as the middle of the tuber.

Bearing in mind that sufficient moisture is a prime requisite for the production of a good crop, direct your cultivation in such manner as will best preserve this condition. Instead of the old method of high ridges, which had no motive except to keep the tubers well cov-

ered, plant deep enough to admit of level culture in the initial stages; when it finally becomes necessary to draw the soil up, do so by throwing a furrow toward the plants from each side so as to make a wide ridge with a slight depression in the center; water is wanted down in the row where the tubers are forming, and not between the rows where it was sent by the old system of pointed ridges. As potatoes are slow to germinate, it is well to go over the ground once with a light smoothing harrow a week after planting, and again just as they appear above the ground. Besides keeping the surface mellow and open this will save much labor in after-cultivation by destroying myriads of weeds that will be just starting into life. Cultivate by throwing the dirt slightly away from the row at first and then returning it so as to have mellow soil close to the hill; afterward run the cultivator often enough to keep the entire surface well mellowed.

Harvesting should be done as soon as the tops are all wilted; if left in the ground longer they are are liable to rot or to become watery and insipid. Dig with a potato hoe, throwing the tubers out in an even row, and leave them exposed only long enough to become well dried. Sort them at once, putting the best into barrels if intending to market at once, or else haul them directly to the place of storage. Select out smooth, medium-sized tubers for seed, and put all small or imperfect ones away to feed to stock.

As a general rule late planting is best for the main crop. The chances then are most favorable for getting the full benefit of the fall rains while the tubers are forming.

It is usually best to market the crop as soon as harvested; their bulk makes repeated handling laborious; prices are liable to go down instead of up, and with the best of storage there is often serious loss from rot.

High manuring is always beneficial, providing it is done intelligently; but the application of fresh barn-yard or stable manures is apt to make the tubers scabby, and engenders trouble from wireworms. The analysis of the ash of the Potato, which is as below, indicates its manurial adaptation:

Potash	59
Soda	1
Magnesia	4.5
Lime	2
Phosphoric acid	19
Silica	2
Chlorine	3

Mineral manures, such as wood ashes, phosphates, and potash salts, will increase the growth and be conducive to health and thrift.

By far the most formidable enemy of the Potato, and the only one which I consider worthy of extended notice here, is the Colorado Potato Bug. These appear about the middle of May, and at once begin to feed voraciously on the leaves and tender stems. As they produce three broods in a season, and as each female lays an average of 600 eggs, it will be seen that it is almost futile to fight them unless preventives are used at the very start. Paris green, mixed with twenty times its bulk of flour or air-slaked lime and dusted over the plants when wet with dew, is the most efficient remedy. Do this upon the first appearance of the pest in the field, and repeat the application as often as washed off by the rain.

THE SWEET POTATO.

The only hypothesis upon which the limited cultivation of the Sweet Potato can be explained lies in the fact that many farmers hesitate to undertake the management of even the simplest hot-bed. For although this was formerly considered emphatically a Southern crop, it is now acclimatized as far north as latitude 40° to 42°. But in the Northern sections it must be started in hot-beds, as the plants can not be put in the open ground until all danger from frost is past, and in the fall the crop must also be secured before frosts come. Although the short season necessitates additional labor in the North the potatoes grown there are usually of better quality (more mealy) and keep better than Southern grown, as they contain less sugar and more starch. The crop is well adapted to the needs of the farmer, for the reason that the principal labor upon it comes at a time when the demands of the other work begin to lessen. Planted throughout the central belt of States about June 1, its principal cultivation will occur after the grain crops are harvested.

The first operation will be the preparation of the plant bed. Select a spot sloping toward the south; if a wall or close fence is immediately on the north so much better. The site should be well drained, so that no water can settle in the pit to cool the manure. A bed 18 feet long and 6 feet wide will be sufficient for 20,000 plants, and will require one barrel of seed. Two and often three drawings of plants can be had from one bed.

Set planks 12 inches wide on edge at each side and across the ends, making the corners square and tight, and secure them firmly in place by driving stakes inside and outside of the frame thus formed. Place rafters across at convenient distances to rest the sashes on; spade out the interior to a depth of 8 inches, placing the dirt evenly around the outside of the frame. For some days prior to filling the bed save all the manure from the horse stables under cover by itself, and about three weeks before the plants are wanted put it in the bed. Pack it in tightly by tramping until 12 inches deep; have it all level and the edges and corners as solid as any. Manure thrown in loosely will heat quicker, and retain heat a less time, besides being more subject to burning than when properly placed. After the bed has stood thus for three days cover with 2 inches of sandy loam or clean woods dirt; cut the seed once lengthwise and place cut side down; place the pieces in rows so that the ends touch and have the rows about 2 inches apart. Cover with 2 inches more of the same soil; water slightly, often enough to keep the surface moist, not wet.

As the Sweet Potato bed is made so late in the season that only a moderate degree of heat is required cloth covers are superior to glass. Prepared cloth costing from 8 to 10 cents per yard is now sold by most seedsmen. Prepare good sashes, each 6 feet long and of convenient width, made so they will fit tightly inside the frame of the bed where they may rest upon cleats, and cover them with the cloth. This cover will retain sufficient heat, protect from frost and cold winds, shed rain (if stretched tightly and sloping toward lower edge of the bed), and prove in every way all that is needed.

The Sweet Potato reaches its highest perfection upon a dry, sandy soil; wet or heavy land will produce tubers of poor quality. Plow deep and work the ground until it is well mellowed; then throw up ridges 8 inches high and 3 feet apart; have the soil in the ridges very fine, free from clods or lumps, and thrown up loosely. This is

not only necessary for the purpose of a good seed-bed, but in properly made ridges the labor of setting plants is reduced to a minimum. As soon as there is no further danger of frost, select a cloudy day, or when atmospheric conditions indicate an early rain, draw the plants carefully from the bed, so as not to disturb the seed pieces, and making openings in the ridges 15 inches apart, set the plants down just as deep as they were in the bed and compact the soil closely about them. Unless an early rain seems very certain it will be best to "puddle" the roots by setting them for a while in a tub of wet earth before planting. Small, stocky plants from 4 to 6 inches high are preferable to those that have obtained a greater growth in the bed. Spaced as above, an acre of ground will require 11,760 plants.

The only cultivation needed at first will be to stir the soil immediately about the plants and along the sides of the ridges sufficiently to break the crust and keep the surface mellow; give one plowing before the vines commence to run, throwing additional soil up against the ridges; after that use the cultivater freely between the rows, narrowing it down as the growth of the vine increases, until the ground is wholly covered by them. Use the hoe freely to keep out weeds and grass if any take root about the hills.

The crop should be harvested before a frost; but failing to accomplish this, if a frost is indicated, go over the piece with sharp hoes and cut the vines loose at the crown of the hill; leave the vines piled up on top of the ridges.

If the ground was put in proper condition primarily the crop may easily be dug either with a fork or a pronged hoe. In harvesting the Sweet Potato it is of the highest importance that it be not handled unnecessarily, or cut or bruised; the juices are so rich in sugar that it is a poor keeper at the best; and wherever the cuticle is broken decay follows rapidly. The best plan is to sort them as taken from the row, placing the marketable tubers carefully in barrels (put them in by hand; don't "dump" them) and remove at once to the place where they are to remain until sold.

Lift the barrels in and out of the wagon instead of rolling, and in every way avoid jarring or bruising. Thus handled and stored in a dry place, with a uniform temperature not exceeding 50°, they will keep well until after midwinter, and the increased price then usually to be obtained will amply repay the precautions used.

For Northern planting it is best to procure Southern seed, as the saccharine qualities become somewhat eliminated by the successive use of Northern-grown seed.

An average yield on good soil may be put at 200 bushels, but crops greatly in excess of this are not uncommon. Prices fluctuate greatly, but are usually sufficiently good to make the crop a very profitable one.

Farm-yard manure, well rotted, may be used in the drill and the plants bedded thereon, or it may be applied broadcast and well worked into the soil. If commercial fertilizers are wanted use such as are rich in potash and apply them about the plants during the early cultivation.

THE CABBAGE.

We may divide cabbages generally into three classes, early, medium, and late; and, leaving the two former to be treated more specifically in the portion of this article devoted especially to market gardening,

confine ourselves here to the subject of late cabbage as a field crop. There is a prevailing impression among farmers that cabbages can not be successfully grown unless plants are started in a hot-bed and transplanted. This is an error, as plants will grow and head equally well if the seed is dropped where they are finally to stand. The advantages of this method are apparent; besides avoiding the labor of preparing hot-beds and transplanting, the consequent checking of growth (which will occur to some degree under the most careful manipulation) is prevented; and should any missing hills occur in the field, it will be found a very great advantage to have plants right at hand with which to fill vacant spaces. By dropping several seeds in each hill a number of plants are started; in the early stages of growth they are subject to the depredations of numerous insects, which might prove fatal to the stand were there only a single plant to prey on; but with a half dozen to each hill the "survival of the fittest" will usually be illustrated.

For late field culture the large varieties, such as Premium Flat Dutch or Marblehead Mammoth, are preferable. For planting as above suggested 8 ounces of seed will be required for an acre; if started in hot-beds an ounce of seed may be relied on for about 1,000 plants. The ground for Cabbages should be made exceedingly rich, as they are gross feeders. A liberal quantity of barn-yard manure should be applied broadcast, and supplemented by the use of a good compost in the hill, or by commercial fertilizers used at the first and second hoeings. Any manure is valuable except that from the hog-pen. If this is used so that it comes in contact with the growing roots it is apt to produce the disease known as "stump-foot." If the ground has previously been cropped with cabbage, turnips, or any of the *Brassica* family, this disease is also apt to be engendered.

Cabbage can be successfully grown upon any good soil, light or heavy, upland or bottom, if sufficient manure is applied; but there is nothing better adapted to it than a strong, freshly-turned sod. Apply all the manure possible, in any event, and thoroughly incorporate it with the soil by deep plowing and thorough harrowing.

Mark out the ground into hills 3 feet apart each way. If compost is used in the hill mix it well with the soil, drop thereon a half dozen seeds and cover lightly, firming it well with the hoe or the foot.

As soon as the plants appear above ground stir the soil lightly between the rows with the cultivator, and with the hoe loosen the crust about each hill and remove any lumps that may have been thrown upon the plants by the cultivator.

When the plants have attained the size of a pipe-stem they will be beyond the reach of their earliest enemies, and all but one good strong plant should be removed from each hill.

The old rule was to hoe cabbage three times during growth, but as they greatly relish tending, a better rule will be to cultivate as often as required to maintain a proper condition of the soil. Draw the soil toward the stems at each working, so as to make broad, flat hills about them. Should a season of drought occur as the heads are forming they will be apt to harden prematurely; then if a hard rain follows a new growth will ensue and the heads burst open. Upon the first indication of this tendency go over the entire piece and start such heads as are hardening by pressing them over to one side, thus loosening their hold upon the ground and checking the rapidity of their growth.

The insect enemies of the cabbage are numerous. The first to trouble it is the small, black cabbage flea, which attacks the young plant as soon as it appears above ground, eating small holes in the leaves and sucking the juices. It may be prevented from doing much damage by dusting the plants with soot or with air-slaked lime, and renewing the application whenever washed off. The leaves, however, soon become so tough they can not penetrate them, and the insects disappear when the plants are 4 or 5 inches high.

The brown cut-worm is often troublesome to early-planted cabbage, but as it disappears about the middle of June, the late crop is rarely troubled. This worm gnaws the stem of the plant off just at the surface of the ground. There is no efficient remedy except to dig them out of the hill where they have manifested their presence. If the seed is sown in the hill as suggested they will rarely destroy all the plants.

Should the season be backward and the plants become checked in their growth, they may be attacked by small green insects known as *Aphidæ*, which sometimes completely cover them. As these usually occur in a season of drought, the best remedies (and preventives) are to keep the cultivator going, water the plants if possible, and dust often with air-slaked lime.

Last and most troublesome of the cabbage pests is the green worm which infests the plant at all stages of its growth.

Many remedies have been suggested, most of them wholly worthless, and some efficacious only occasionally. The greatest satisfaction will be obtained by the use of good pyrethrum powder mixed with three times its own weight of flour or lime and appplied with a bellows. Four pounds of this mixture will be sufficient to go over an acre once; but the dusting should be repeated often so long as any worms remain.

In harvesting, cut off the head of the cabbage close to the stump and remove the coarse outer leaves. As the crop can be marketed by the car-load in any large city at almost any season, they may be loaded and shipped as taken from the field, thus avoiding rehandilng. If it is desired to hold them for a later market they may be stored in a cool shed where they will not freeze, or in small piles in a cool cellar, or buried in trenches in the ground. The waste product of the cabbage crop, including the outside leaves and such heads as have not hardened sufficiently for market, make excellent food for stock, but should be fed to milch cows in limited quantity, as it may affect the flavor of the milk.

BEANS.

The culture of field beans is already an industry of great importance in certain sections, and as they can be grown over a very large area of this country there is no reason why the crop should not become one of general value to farmers. The soil best adapted to their growth is a stiff clay, but it should be good land, well manured; fresh yard manure, however, is not advisable, as it will cause too great a growth of vine at the expense of the seeds. On light soils beans are also inclined to run greatly to vines which droop down on the ground, and if a wet season ensue while the pods are filling they will mildew. Upon a clay soil the vines will grow short and stocky, holding their pods well up, and the crop will ripen earlier and more evenly. The two kinds principally grown for a field crop are the

common white navy or pea bean and the large marrowfat. The navy bean is somewhat easier of culture, as the growth of vine is more compact and less liable to lodge, but the marrowfat will yield more bushels per acre and bring a better price.

The ground should be prepared as for corn the latter part of May, and about June 1 drill in the seed at the rate of 1 bushel to the acre, in drills far enough apart to admit of horse culture. If the weather is favorable and the ground moist they will be up in a very few days, and as they grow very rapidly cultivation should begin at once. This should consist in merely keeping the surface of the ground well stirred, and should be very thorough until the vines commence to blossom, as it must then cease. The blossoms are very tender and are easily knocked off by passing between the rows, and the crop may be more hurt than helped by subsequent workings.

As soon as the majority of the pods are ripe begin harvesting. The most satisfactory method is to pull the vines by hand and haul them at once to barn or shed, where they must be piled up loosely so the air may circulate freely and prevent them from accumulating dampness. They may be most rapidly gathered by driving astride of one row, and three men working behind the wagon gather the center row and two on each side, as in corn-husking. Harvest them only on a dry day, and do not begin in the morning until the dew is off the vines. After they are under cover examine frequently to see that they are keeping cool and dry, and when properly cured thrash out with flails. A dry day must be selected for thrashing, as bean pods become tough or "in case" whenever there is much moisture in the air, and the seeds will not then shell out properly. After thrashing clean with a fanning mill, and if there are many discolored beans pick them out by hand. Put them in bags or barrels for market.

Beans may be stored anywhere and for almost any length of time, providing they are kept dry. They may always be readily sold in any large market, at any season, and in any quantity. Bean vines make an excellent fodder for sheep, but are not relished by cattle. Being very rich in nitrogenous elements, they make a valuable addition to the compost heap.

TOBACCO.

As this is a crop of increasing importance over a widely extended area, being now grown in nearly all the States and Territories, it may be made a valuable adjunct to the work of many farmers; but the directions for its treatment would need to be so exceeding comprehensive, covering the subjects of seed bed, soil, cultivation, cutting, topping, hanging, curing, and stripping, besides description of the necessary sheds for handling and curing, that I have thought best not to go fully into the subject here, but to offer only some general suggestions. A farmer who has from 1 to 5 or more acres of deep, warm, loamy soil and has available the requisite labor for handling the crop almost constantly from the time of setting the plants (about June 1) until it is taken into the sheds (which must be done before frosts come), and again for the processes of handling and preparing for market during the winter, will usually find it very profitable. The fact of being able to use his labor to such advantage during the latter season will in itself be a large item of gain.

Those intending to engage in tobacco,culture will do well to study the subject thoroughly with the aid of some good treatise, to consult

practical growers, and to familiarize themselves with the course of the markets. The most common method of tobacco growing in this section is for the farmer to furnish the land, team, and implements to laborers, who put the crop in, cultivate, and prepare it for market for one-half the proceeds. In this arrangement the farmer usually fares better than the renter, as the value of the labor is much more than equal to one-half the cost of production.

MARKET GARDENING.

We will now pass to the consideration of market gardening in its proper sense, *i. e.*, the cultivation of vegetables to be sold immediately in their fresh state. This may properly and advantageously be made a special department of the work of any farmer who is properly situated as to available markets.

The most desirable location is near a good town, where the products may be taken as soon as gathered and either sold to a dealer or retailed direct to the consumer. This is more profitable than growing for shipment to distant markets, as cost of packages and labor of packing is avoided; there are no express charges or middlemen's commissions to pay; no losses from produce damaged during transportation, or from remaining in store so long as to become unsalable.

It is always well, however, for the gardener to establish acquaintance with a good commission dealer in his nearest city, to whom surplus produce may be sent in event of the home market not requiring his entire supply.

For the market garden the best land on the farm will not be too good; fit this for cultivation as well as you may, by draining, deep plowing, thorough tillage, and heavy manuring, and it will yet pay you to make it better still. In market gardening the last load of manure always pays better than the first one. Preferably the piece should be level, and as best adapted to all vegetable crops, should be a deep, mellow loam. In arranging for the labor here, in connection with the farm, there should be at least one hand detailed (whether more than one will depend upon the extent of the garden) whose sole duty it is to attend to this work. He should be the most intelligent man upon the place. Robustness or ability to perform heavy labor is not so important as that he should be industrious, faithful, and vigilant in attention to minute details.

The area to be devoted to gardening and the portion for each vegetable can best be determined by estimating the amount of each product that a given space will yield. Thus, root crops to be sold by the bunch, such as young beets, carrots, onions, parsnips, radishes. salsify, and turnips, may be averaged at about 50 bunches to each 100 feet of row, and of other vegetables as follows to the 100 feet:

Beans and peas	bushels	2
Lettuce	heads	100
Peppers	dozen	100
Cabbage and cauliflower	heads	50
Celery	bunches	200
Cucumbers	dozen	50
Sweet corn	do	8
Tomatoes	bushels	5
Potatoes	do	2

This, of course, is only an approximate estimate and merely intended as a comparative guide in making the allotment.

Of the above the seeds of cabbage, cauliflower, lettuce, peppers, celery, and tomatoes should be started in hot-beds, and the first supply of radishes, beets, lettuce, and carrots wholly grown therein. Earliness is almost the chief consideration of the market gardener, and as good hot-beds are the means by which this end is attained, too much care can not be given to their preparation.

For early hot-beds select a location on well-drained land, sloping slightly to the south; excavate to the depth of 2 feet and pile the dirt up evenly about the outer edge. Then line the pits thus made at the sides and ends with boards, and have them extend 1 foot above surface at the rear and about 8 inches at the front. Secure them in place by stout posts driven into the corners and along the sides, and nail the upper tier of boards to the posts; then draw up close to these upper boards the earth that was thrown out from the pit, so that they shall be tightly banked all around. Upon the bottom of the pit throw some dry straw, litter, or coarse leaves to keep the manure from the cold ground. Then put in fresh manure from the horse stables, and pack it down as fast as put in until the entire mass is 2 feet deep. Bear in mind that the more evenly and solidly the manure is compacted the steadier and more lasting the heat will be. Should the manure be somewhat dry, sprinkle it enough as it is put in the pit to moisten the whole slightly, but avoid soaking it. The manure in, put on the sashes and leave the bed three or four days for the first violent heating to subside; then put on the covering of soil, which should be light and rich, 3 or 4 inches deep. While glass is undoubtedly the best covering for a winter hot-bed, or for the use of the "all the year round" gardener, it is not essential for spring hot-beds to be started, say, the middle of February. The patent plant-bed cloth before mentioned will answer every purpose. It is much less expensive than glass, not so liable to destruction, and with it there is not so much danger of burning off the plants in the hands of an inexperienced operator. The best shape for a hot-bed is a rectangle, 6 feet wide, and as long as may be required. Put rafters across the bed at convenient distances, set slightly below the edge of the boards, so that when the sashes are on the top will be tightly closed.

In the hot-bed it will be found much better to sow the seed in rows than to scatter it about. By this means it is possible to stir the soil, if desired, to properly thin the plants, and to remove all weeds.

Adjacent to these beds prepare cold frames somewhat greater in extent, into which the plants may be picked out and given greater room for development, and where they will become gradually hardened before being planted in the open ground.

For cold frames the ground should be spaded a foot deep and well pulverized; then rake in a liberal surface dressing of hen manure, guano, or rich compost; then build a frame of boards a foot high, and closely joined about it, and cover in same way as hot-beds. The management of a cold frame is very simple; give plenty of light, air, and moisture; cover at night and on cold, windy days.

The object aimed at is not so much to force the growth as to get the plants well furnished with roots and gradually accustomed to the open air.

About the middle of February the seeds of early cabbage, cauliflower, celery, lettuce, peppers, and tomatoes should be sown, and as soon as the plants are large enough to handle transplant them into cold frames, giving ample room to each. If crowded they will

send up weak, spindling stems instead of developing the hardy, stocky growth that is desired. Sow beets, forcing carrot, and radishes very thinly in the hot-bed, and grow the first supplies for market there. More air must be given here than in the plant-bed, and a more moderate temperature maintained, or the tendency will be to grow tops instead of roots. If found necessary to thin the beets they may be profitably transplanted either into cold frames or to the open ground. If a market is close at hand it will also pay very well to sell the young beets as "greens."

I will now proceed to notice, with brief cultural directions, each of the principal vegetables adapted to the business of the market gardener, taking them in the order in which they will demand attention in the spring.

The Radish.—This excellent vegetable, so palatable in the early spring, is so easily grown that any directions for its culture seem almost superfluous. The seeds may be put in the ground as soon as it can be worked in the beginning of the season, and succession crops should be sown to provide a supply through the spring and early summer months; later there is little demand for them.

Sow the seeds an inch apart in narrow rows and cultivate with the hoe or small garden plow. As soon as the rough leaf is developed thin to 2 inches apart, and commence marketing as soon as any roots are large enough. They come on very rapidly and become strong and pithy when left in the ground too long. As above suggested, the earliest supply may be grown in a moderate hot-bed.

The Beet.—This root requires treatment similar to the radish, but is a much more valuable and satisfactory crop. Sow the seed as early as possible in narrow rows and cover 2 inches deep. As soon as large enough to handle thin out to 3 inches apart, and reset the plants taken up at once in other ground to come on for a second crop. Make successive sowings, commencing with the Egyptian Turnip Beet for the earliest and following with the early Blood Beet for main crop. For fall and winter use beets may be sown as late as July 1, and they are salable throughout the year. Like the radish, a first supply may be grown in the hot-bed.

Spinach.—There is a fair demand for this in most markets in the early spring, as it supplies the need for green food until early peas, beans, and cabbage appear. The seed may be planted as early as the ground can be worked. It is often sowed broadcast, but is better drilled in narrow rows, as it should have at least one hoeing. The plants may be left growing very thick and thinned as wanted for market. Spinach may also be planted in the fall, protected by a slight mulching through the winter, and will then be the first green thing to start in the spring.

Lettuce.—As this plant is in especial demand during the early spring months, an out-door planting does not usually come into market in time to be of great value. Hot-bed and cold-frame plants should be ready for setting very early. Transplant them to very mellow soil in rows far enough apart to be worked with a garden plow, and have the plants a foot apart in the row. A sowing may also be made in the open ground to supply the later needs of the market. Sow the seeds 2 or 3 inches apart in the drill, cover lightly, and thin out as soon as the plants are above ground.

The Onion.—The most profitable method of growing the onion is from the seed; but the market gardener, to supply the early demand, will be compelled to use sets extensively. The ground for onions

should always be superlatively enriched. All manures are good, but that from the hog-pen is the very best. The soil should be a strong loam, plowed deep, compacted, and then made very fine on the surface. Mark out narrow lines and plant by merely pressing the sets by hand well into the soil about 2 inches apart. Keep them entirely free from weeds, and stir the ground frequently with the hoe or garden plow, but not more than an inch deep. As soon as the bulb commences to swell and a good green top is developed commence pulling and marketing in bunches. For the midsummer market onions may be had by sowing the seeds of some quick-growing sort, such as the White Queen. Put the seed in quite thick, as only medium-sized bulbs are wanted. For the fall and winter supply sow the seed of any of the larger varieties; keep the rows clean by hand hoeing and weeding, and thin to 3 inches apart as soon as the stems are as large as a rye straw. They should be sown early, as the seed is slow to germinate, and a long season is needed for the full development of the bulb. This late crop may be harvested as soon as the tops die down. Throw the onions in rows and leave them to dry in the sun for three or four days; then house them by piling lightly in a cool, dry room. The amount of hand labor requisite for the successful production of an onion crop from the seed renders it advisable that a beginner in their culture should not undertake a very large area. When properly handled it is one of the most profitable crops grown, as from 600 to 800 bushels per acre is not an unusual yield.

The Carrot.—In most small markets the demand for carrots is quite limited, yet as with good depth of rich soil they yield very largely, it will always pay to give them some space. For general crop the long orange is the best and most productive variety. I have found it best to sow the seed upon ridges made as for sweet potatoes, as in this manner the requisite depth of loose soil is best attained, and the roots are much easier to dig than when wholly below the level surface. Have the ridges as near together as horse culture will permit; drill the seed in by hand and cover lightly; thin to 2 inches apart; keep clean by the use of the cultivator and the hoe; dig soon after first frosts by running the plow along one side of the ridge and throwing the dirt away from it, when the roots may be easily pulled by hand, or thrown out with a spading fork. Carrots may be sown any time from the opening of spring to the middle of June, but the longer season they are given the larger the growth. Besides their value for market they are exceedingly desirable as an addition to the food of all stock. They are particularly beneficial to horses and colts, and when fed to dairy cows impart the desirable golden color to the butter without any resulting bad flavor.

The Parsnip.—Parsnips are decidedly more salable than carrots, there being a very steady demand for them in most markets throughout the fall and winter. The sowing of seed and subsequent culture may be the same. Unlike the carrot, however, it is benefited by frost and may be left in the ground as late as possible.

Salsify.—The profitable culture of this crop is also limited by reason of the small demand. Planting and entire treatment may be the same as for carrots. Among such as are familiar with this root it is esteemed a most delicious vegetable, and a gardener supplying a home market might find it to his interest to introduce and cultivate a taste and consequent demand for it among his customers.

The Pea.—This is a most valuable market crop in all localities. It is usually the first of the open ground crops to bring in cash returns

of any amount. The smooth, hardy varieties may be sown very early and successive plantings made to carry the crop well into the summer. During the hot, dry weather of midsummer it will be difficult to grow them successfully; but if the weather is favorable a planting of a very early sort made the latter part of August will bring a good paying crop for early autumn. The early dwarf kinds do not need bushing, and in fact market gardeners do not often bush peas at all; but the increased yield to be obtained from such as the Marrowfat and the Champion of England will amply repay the labor and expense of the supports. An excellent arrangement is to plant in double rows 8 inches apart with the bush between; leave a space of 3 feet between each double row for the cultivator. Sow quite thickly in the row and cover early peas 2 inches deep, and the late ones 3 to 4 inches; cultivate by drawing the soil slightly toward the stems at each working. Varieties are almost too numerous to discuss here; any good seed catalogue will give very reliable information regarding various early, medium, and late sorts. Most of the extra early kinds show very slight variation from one main type.

The Bean.—Green or snap beans are salable in all localities from the time of their first appearance until frosts put a stop to the supply, and while the later prices are not so good, the crop will usually pay well throughout the entire season, as it is productive and easily cultivated. Sow in rows far enough apart to permit of horse culture, and drop the seeds 2 inches apart in the row. Make successive sowings every two weeks up to the 1st of August; cover the seeds lightly at first, but deeper as the season advances. The hardiest early kind is the Mohawk, which will stand a slight frost, and the best are the Red Valentine and Golden Wax. Beans should be cultivated thoroughly from the start until they begin to blossom; but never work them when wet, as any dirt thrown upon the pods will discolor them and injure the sale.

The Lima Bean is not usually given as large a space by the market gardener as its value will warrant. Perhaps one reason for this is the expense of getting the poles for any large area. If the farmer has a piece of woodland where they may be cut and prepared during the winter the expense will be materially lessened. The value of the Lima as a green bean for cooking is not generally known. The flavor is more rich and buttery than of any other variety, and the ripe shelled beans always command a good price.

The greatest care is necessary in starting the seed, as in cold or wet ground it is very liable to rot. They succeed best in a sandy loam, in which hills should be prepared about June 1, 3 feet apart each way, with a good rich compost well mixed with the soil. Plant five or six seeds in each hill, merely pressing them under the surface; cultivate thoroughly and at the last hoeing draw the soil well up about the vines. If not sold green, but left for a matured crop, they should be gathered before a frost. Pull the vines down and stack them until well dried, then pick off the pods and shell out by hand.

Sweet Corn.—While there are many garden crops that will pay a larger return per acre, there are few that will pay better for the labor required or more surely yield a profit than this. The demand for it is continuous throughout the summer and well into the autumn. The best method by which to secure succession crops is to plant first a very early sort, a little later make a general planting of early medium and late, and supplement this further by a midsummer

planting of an early kind. By this means you will have a continuous supply until frost. The best early varieties are Cory and Early Minnesota; for medium, Crosby's; and Stowell's Evergreen for standard late. Early corn may be planted in drills and quite close, but the best success with large, late kinds will be had by planting in hills 3 feet apart each way, and three to four seeds to a hill.

The Cabbage.—The preceding pages have already comprehensively treated of the cultivation of the cabbage as a field crop, so that here I will only give a few suggestions as to its especial management in the market garden. Plants started in the hot-bed in February and picked out into cold frames and there given room to develop a stocky, hardy growth may be transplanted to the open ground as soon as danger from severe frosts is passed. For medium crop the plants may be started in cold frames and set in the open ground in May or by the 1st of June. Of the early varieties Jersey Wakefield is the standard and best. These may be set 2 feet apart in the row, and rows 3 feet apart, giving 7,350 plants per acre. Fottler's Brunswick is a good medium sort, very reliable for heading. Plant a little farther apart than the Wakefield, using about 5,000 plants per acre. Frequent cultivation, as before noted, and close attention to insect enemies are essentials for success in cabbage-growing.

The Cauliflower.—Although somewhat difficult to grow, when the effort is attended with success the cauliflower is one of the most profitable vegetables for the market gardener. Start the plants in an early hot-bed and properly harden them off in a cold frame and set in the open ground at same time as early cabbage. As the crop is much more valuable than the cabbage, extra manuring in the hill, extra cultivation, and extra care of the plants will be well repaid. They are subject to the same insect enemies as the cabbage, but beyond this there are no particular difficulties in the way during their early growth. But when the heads begin to form the utmost watchfulness is necessary to preserve their delicate creaminess and curd-like quality. They are then exceedingly impatient of drought and extreme heat. They should be kept well watered and the outer leaves drawn up and tied loosely over their heads. Stir the ground very often and keep it drawn up about the stems. As soon as fully formed they must be cut and marketed at once and without any exposure to the sun, as they rapidly wilt and deteriorate in quality. Good cauliflower always sells well and commands a good price.

The Cucumber.—On account of shipments from the South it is usually difficult for Northern growers to get cucumbers into market early enough to secure the best profit. The demand ceases almost entirely with the coming of very hot weather, and does not recommence until autumn, when small ones are wanted for pickling. Forcing is attended with serious drawbacks, as the room required in a bed for growing any number would be considerable, and successful transplanting is very difficult, owing to the tenderness of the stems. The seeds may, however, be started upon sods in the bed, and after all danger of frost has passed, set the entire sod into a loose, rich hill. For starting in the open ground the seeds may be planted about May 1, and again about July 1, for the fall crop for pickling. The hills should be 5 feet apart each way, spaded deep and well filled with good compost. Drop a half dozen seeds in each hill and thin to four good plants when well started. Cultivation consists in keeping the ground loose, free from weeds, and well drawn up about the stems. The vines are often troubled in the early stages of growth

by the cucumber flea, which can be driven away by dusting with air-slaked lime or soot; and by the striped cucumber bug, for which use arsenical poisons.

The Tomato.—The ease with which the product can be handled and the fact that it may be sold both green and ripe renders the tomato a favorite crop with all gardeners. The early prices are always good, and although they may drop quite low in September and October, when the bulk of the crop is on the market, yet its immense productiveness tends to make it profitable throughout. For the earliest picking start the seed in a hot-bed and transplant into cold frames, and handle so as to have the plants already in bloom when put into the open ground. The usual method of cultivation is to set the plants level and gradually hill the earth up to them. But a better way is to set them on the tops of ridges so that the vines may droop down over the sides. This will let in the sun and air, and will keep the fruits from lying down upon the ground in such manner as to cause rotting. Planted in this manner the ridges should be 5 feet apart, and the vines 3 feet apart in the row. Undoubtedly the best sort for general cultivation is Livingston's Favorite.

Green tomatoes are largely sold for pickling in the autumn. If in the vicinity of a canning factory it would be profitable to arrange with it for the purchase of your surplus supply both of tomatoes and sweet corn.

Turnips.—It will pay to grow these only on a limited scale for early market. The Early Purple Top Munich is the earliest variety, and may be sown in narrow drills, thinned to stand 6 inches apart in the row, and cultivated with a garden plow. For main crop sow up to the 1st of August, scattering the seed lightly in any vacant space, or between corn or potato rows at the last working. This crop will cost nothing but the seed and labor of sowing, and if too many are grown for the home market they can be shipped in bulk to the nearest large city and usually sold at a price which will give a fair profit. Failing in this they make an excellent food for sheep, and may be used as an addition to the rations of all cattle.

The Egg Plant.—This vegetable is annually growing in favor, but the demand is not yet sufficient to make it profitable to grow in large quantities when cultivated only for a home market. Start the seeds early in a hot-bed by themselves, as they require a higher temperature for germination and greater warmth during the early stages of growth than almost any other vegetable. They must be hardened off in cold frames very gradually and put in the open ground about June 1 in hills 2½ by 4 feet apart, and cutivated by frequently drawing the soil up about the stems.

The Pepper.—The treatment and conditions essential to the growth of the pepper are similar to those of the egg plant, excepting that it matures more rapidly and may therefore be sown somewhat later. Under favorable conditions the pepper will mature if sown in the open ground so late as the middle of May, but it is much better to start the plants in a bed and not put them out until the ground is thoroughly warm.

Celery.—This is unquestionably the most profitable of all vegetables which can be grown as a second crop. Land from which an early crop of peas or potatoes has been taken can readily be fitted for celery. The great needs of the plant are high manuring, careful handling, and plenty of moisture. The plants for an early crop may be started in a mild hot-bed, later ones in a cold frame, and for late

fall and winter use sowed in a well-prepared bed in the open air. In either case the soil of the seed-bed should be very free from weed seed, as the celery plant when young is very slight and difficult to work about. Scatter the seed thinly in drills 9 inches apart, so as to admit working up the soil with a light hoe or rake. As soon as the plants are large enough to handle transplant into a rich, open bed, setting them in rows 1 foot apart and the plants 3 inches apart in the row. As the object of this transplanting is to develop a stocky growth, the tops should be shorn back once or twice and the plants well watered and cultivated. When they have attained a height of 6 inches set them out in rows 3 feet apart and 6 inches between the plants. This should be upon ground particularly capable of retaining moisture. Plow very deep and work it until the last degree of fineness has been reached. Mark out furrows 6 inches deep and set the plants slightly deeper than they stood before. In taking up the plants moisten the bed thoroughly before commencing. Then insert a fork well under the plant and secure not only the whole root but enough damp earth to protect it and assist it to start quickly in its new location. Now give frequent clean cultivation and, if the weather is dry, water abundantly. In a few weeks the plants will commence spreading and require the first operation of handling. This is done by gathering the stalks closely together and drawing the earth up to one-third the height of the plant, and there firmly compacting it. The greatest care must be taken not to let any dirt fall into the heart of the plant or rot will ensue. This operation must be repeated, as the growth increases, sufficiently often to keep the stalks always well together. Gradually draw the earth higher, so that by the time their growth is completed nothing will be visible but the green foliage at the top.

Marketing may begin as soon as the blanching is completed, and the entire crop sold directly, or it may be stored in pits and cellars and sold throughout the winter and spring. The dwarf kinds, such as White Plume and Golden Dwarf, are far better than the large varieties, as they are easier to handle, usually blanch better, and are more crisp and sweet.

Rhubarb.—This is a valuable plant for the gardener, as after a bed is once started it will yield for a number of years and require very little attention. Plants may be grown from the seed or procured from a nurseryman. The latter method would be preferable for one engaging in its culture on a limited scale. Plants may be set either in the autumn or spring; if in the autumn, a slight cutting can be had the following season; but if in the spring, no cutting should be made that year. Rhubarb is a gross feeder and will thrive on any kind of manure. The plants should be set 4 feet apart each way and the ground kept well cultivated. In the fall, after the foliage has died down, cover the crowns of the plants with a good supply of rich compost, and in the spring work thoroughly into the soil a liberal top-dressing of same. Cut away the seed stalks as soon as they appear, and the result will be a more vigorous and crisper growth.

Potatoes.—Both Irish and Sweet Potatoes have already been so fully treated that further cultural details are unnecessary here. They are both valuable crops to the market gardener, and should have ample space allotted them. The principal profit is to be secured from Irish Potatoes by having an abundant supply ready for the very early market. To accomplish this, plant early, give the best possible cultiva-

tion, and use both in the drill and along the row at the first working a liberal supply of some special potato-crop fertilizer to push them rapidly forward.

RAISING PLANTS FOR MARKET.

This is a legitimate branch of the business that is too often neglected. Some seem to think that by selling plants to others they lessen their own market for produce. Cabbage, tomato, pepper, and sweet-potato plants may be most profitably grown, and most farmers or small village gardeners who desire a small supply of these for their own gardens would much rather pay a good price than to bother with a hot-bed. The cost of growing the plants amounts to very little besides the labor, and when a gardener is growing a large supply for his own use the labor of starting a few thousand additional will hardly be felt.

The growing of asparagus, although it is a most valuable market crop, I have not thought best to treat here, as these notes have been prepared mainly as suggestions to farmers who might desire to experiment with new methods of increasing their profit; and such would not generally in the beginning consider it advantageous to start a crop that would require some years to mature, and consequently to solve the question they are asking. The growing of small fruits may also enter particularly into the work of the market gardener or small farmer. Of these, strawberries and blackberries will be found most generally profitable, especially by such as are near a good home market.

MARKETING.

Before the opening of the season determine definitely, by proper investigation, what plan you will pursue in this respect and adhere to it closely.

Either arrange with a good commission dealer in your nearest city to handle your entire product, or sell outright to your local dealers, or retail direct to the consumer. Each plan has its advantages and the selection must depend upon the location and circumstances of the producer. In any event offer nothing but fresh vegetables for sale; it will pay better to feed it at once to the hogs than to offer anything of poor quality and thus injure your reputation. Before starting for market put everything in attractive shape; tie roots, etc., in neat, well-shaped bunches of uniform size, and put other produce in boxes or baskets.

FERTILIZING.

As it will be futile to attempt the continuous production of valuable crops unless due attention is from the start given to maintaining the fertility of the soil, this subject is worthy of the most serious consideration.

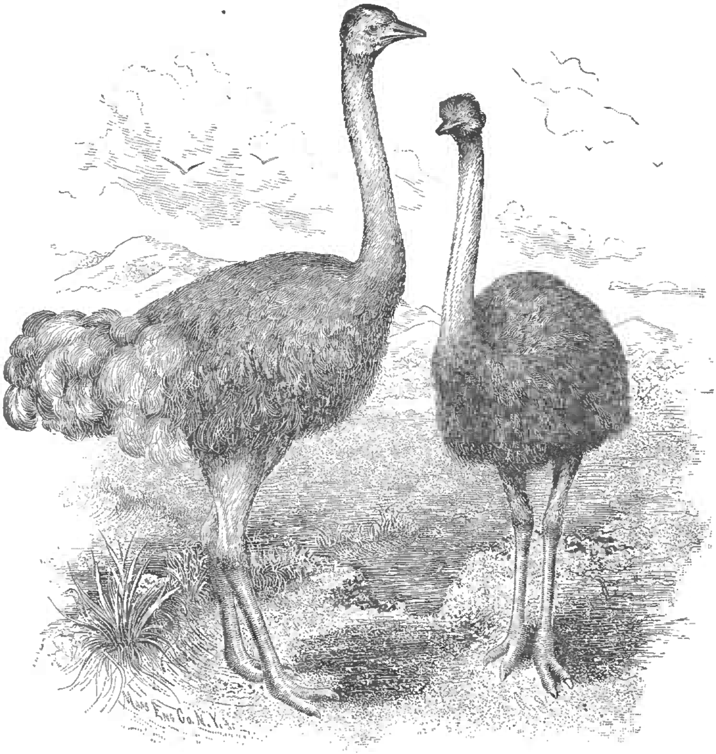
Exclusive reliance on commercial fertilizers is exceedingly expensive, and in many towns the value of stable manure is becoming so well known that it is very difficult to obtain any large supply. If farmers would awake to the fact that they can save and manufacture a vastly greater amount of fertilizing material than they now do they would materially advance their own interests.

The following table, showing the average annual quantity of manure produced by certain of our domestic annimals, is suggestive:

Animals.	Pounds.	Animals.	Pounds.
Horses and mares	6,048	Calves	1,680
Colts and fillies	4,199	Sheep	748
Mules	4,480	Lambs	330
Bulls and oxen	6,720	Hogs	1,904
Cows	6,508	Sucking pigs	896
Young cattle	3,248		

Thus a well-stocked farm, say of 100 acres, carrying 4 horses, 1 colt, 1 bull, 4 cows, 3 yearlings, 2 calves, 10 sheep, 10 lambs, 20 hogs, and 20 pigs would have produced upon it in one year the enormous amount of 141,338 pounds of solid and liquid excrement. Let this be composted with one-fifth its weight of bedding and absorbents, and it would give in round numbers 85 tons of manure. Kept under cover so as to prevent leaching and properly treated to prevent loss of nitrogen by heating, this manure would be worth, according to analysis of the Ohio Experiment Station, $3.27 per ton, or its total value would be $277.95. The value of this product, however, can still be greatly increased by carefully adding to the contents of the compost pile or manure pit the vegetable refuse of the farm.

Pea, bean, and potato vines, turnip, carrot, and beet tops, straw, and forest leaves all contain some degree of fertilizing elements, and the farmer or gardener who houses his stock in such manner that there shall be no waste of manure, who cares for it after it is produced instead of throwing it out to leach away beneath the eaves of the barn, and who takes the trouble to combine with it the otherwise waste products of the farm is the one who will best succeed in applying the principles of intensive cultivation to his land.



OSTRICH FARMING IN AMERICA.

By T. C. DUNCAN, M. D., Ph. D.

"A car-load of ostriches passed through this city yesterday" was the first news to many citizens that the ostrich industry was invading our country. That was four years ago. The curious learned that these importations were all the way from South Africa, and that they were not wild ostriches for show, but tame ones, and on their way to California, where it was hoped to naturalize them and farm for feathers.

The inquisitive learned that this cargo of giant birds was most precious. Like valuable horses they were carefully confined in padded cars and attended by experts. "They are worth their weight in gold" settled the question as to their value.

The visitor to California is to-day surprised to see large troops of native and acclimated ostriches. The ostrich farms are at present located in southern California, near Los Angeles and San Diego, and their success establishes a new agricultural industry of great promise.

Most people have read about the ostrich, "what time she lifteth up herself on high, she scorneth the horse and his rider," and would infer that ostriches are untamable. Ladies know something of the value of elegant ostrich plumes. Possibly they have heard that there was a threatened extermination of the wild birds for their plumes, as befell the buffalo for their skins, but did not know that the wise ones of South Africa set about domesticating this most valuable feathered bird.

Ostrich farming is now one of the largest and most profitable industries of that country. When we know that the exportation of feathers alone is annually millions of dollars, and that a single bird will produce each year 10 per cent. of its value in feathers, to say nothing of the increase, is it any wonder that a pair of breeding birds command the fancy price of $1,000 to even as high as $2,000, and that ostrich farming is a most lucrative business?

With these facts before us we can get a little idea of the enterprise and daring that inspired the pioneers in ostrich importation to the untried shores of America.

The introduction of ostriches into America was slow. The attention of a former Commissioner of Agriculture* was called years ago to this industry, and he tried to interest the Government in the enterprise, but it seems without effect. Why should not this Government have experimental farms for ostriches as well as for fishes and

*General Le Duc.

seeds? Kaffir corn has been introduced, why not the animal or bird that has brought this corn prominently into notice?

In 1881 and 1882 the American consuls to Algiers, Cape Town, Buenos Ayres, and other points collected a mass of facts that presented the advantages of ostrich farming in a strong light.

Possibly these inquiries and recommendations had something to do, directly or indirectly, in what soon followed.

THE FIRST OSTRICH FARM IN AMERICA.

The history of ostrich farming in America is about as follows, as told by the brave men who risked large sums of money in the enterprise.

As America took one-half of the millions of ostrich feathers, it occurred to Dr. Charles J. Sketchly, who was, before the Boer wars, one of the largest ostrich farmers in Africa, that if ostriches could be successfully exported and naturalized in America the profit would be immense. The duty on feathers would be avoided, thereby adding at least 25 per cent. to the income.

In 1882 he started from Cape Town with a troop of 200 picked ostriches on their way to South America, and after a long and tedious voyage via Buenos Ayres arrived at New York in December; and there shipped these delicate tropical birds overland via Chicago and Omaha to the coast; a total distance of 23,000 miles. The ordeal was a most trying one, but 22 arrived in California in fair condition and were at once taken to Anaheim. A company was soon formed, the California Ostrich Company, representing $30,000 capital, with Dr. Sketchly as superintendent.

The farm upon which they were placed was of about 600 acres. The birds were chiefly confined in small pens forming an L, with twelve compartments. These inclosures were walled around with planks standing about 4 feet high. These planks were 12 inches wide by 3 inches thick. An ordinary fence would not resist them, as they sometimes, especially when frightened by dogs, ran against it with great force. Ostriches are mortally afraid of dogs, and hence this animal is prohibited from the vicinity of the ostrich ranch. The small inclosures usually contain each one pair of birds; sometimes, especially during the breeding season, two females are placed with one cock.

The first year these birds resided in America they presented the company from April 12 to October of the same year with 270 eggs. The first chick was hatched July 28, 1883. It was quite amusing to see the pioneer American ostrich chick begin its career by feasting on broken sea shells; but it finally in a few days took to chopped clover and corn meal.

THE SECOND OSTRICH FARM.

The arrival of so large a troop of ostriches in New York naturally created wide-spread interest. About that time, or while those ostriches were on their way to America, another company, the American Ostrich Company, was set on foot in Maine, with Mr. E. J. Johnson as manager. He went to Africa and spent a year studying the habits and management of these "birds," as they are called. He informs the writer that he started with 23 birds and "landed at New Orleans December, 1884, after a voyage of fifty-three days. The birds were confined in the vessel sixty-three days, owing to delays

at the Cape. He was assisted during the voyage by two shipwrecked sailors. None died on the voyage. This is remarkable, and is the only instance, except when 4 birds were sent by steamer to Australia. They made the trip in twenty-four days. The usual loss is about 25 per cent."

While at New Orleans resting the birds Mr. Johnson had many tempting offers to locate in Florida, Louisiana, and Texas, but he concluded to go to California, as perhaps most similar in climate to the natural homes of the birds. He therefore took the Southern Pacific Railroad and reached San Diego without accident.

They were left corraled in the city of San Diego, while he explored the county for a suitable location for their permanent settlement, and which he finally found in the valley of the San Luis Rey, about 7 miles from the town of Fall Brook. Here the clear, dry air, the good water, and the shelter afforded by the Santa Rosa hills furnished the proper conditions for the establishment of an ostrich farm. Here the birds have thriven, the old ones maintaining apparently their natural vigor, and the American-hatched being at two years (the ostrich matures at four and five years in the female and male, respectively) unusually fine, both in size and quality of feathers. The breeding birds are kept paired in corrals of an acre in extent; those of one and two years are left a range of some 30 acres on the mesa, while the small chicks are allowed to run with the other dooryard fowls, making a most curious and unusual combination. A visit to the farm repays the tourist, as one sees then the ostrich in its various stages of development, and in something like its native freedom.

A writer describes this second ostrich farm some time after as follows:

Eight miles from Fall Brook is a bit of Africa dropped down between the hills. At least it requires but a small stretch of the imagination to think of the ostrich ranch as a patch of the dark continent. A little valley encircled by barren hills, a herd of ostriches feeding, the old adobe where the incubators are kept, pomegranate trees, and passion vines climbing over the low house, all make up a picture very unlike the conventional type of American landscapes. The birds seem to take kindly to their adopted home. There are about 40 kept at the ranch at present. The old birds are placed in pairs in their several pens, and only the young are allowed to wander over the grounds. One pair have a nest hollowed out in the ground, and are patiently sitting on a dozen eggs, the male bird taking charge nineteen hours out of the twenty-four.

DIFFICULTIES OF ACCLIMATIZATION.

The long journey seemed to affect the vitality and fertility of the birds of both importations. Dr. Sketchly writes:

The second year of my experiment with the first birds imported I reared 58 young birds. Some of these will now soon begin to lay.

In Africa there would have been 200 to 300 increase in that time. Mr. Johnson says that his birds were selected breeders, and that he was well acquainted with them before buying, having spent a year on one of the best farms at the Cape.

Yet the reproductive powers of the birds are greatly impaired by the arduous trip. The increase has been exceedingly slow. Our birds have been paired off three years and more, and although I have a few very fine two-year-olds, a large proportion of the eggs have thus far been unfertile, or, when fertile, not strong. Four of the African birds have died from consumption of lungs and stomach, contracted on the voyage. My experience is that it has thus far (1887) been a long, hard pull, and that I am just beginning to see daylight.

OBSTACLES IN THE WAY.

To add to the discouragement the prices of ostrich plumes fell to a small amount. The little bird feathers became all the rage with

the ladies, so the sale of ostrich plumes, the chief source of income in ostrich farming, was consequently meager; but the fashion is now setting the other way, and choice plumes will be in good demand at fancy prices.

Here were 45 birds that in Africa would have been very prolific. In the first two years 600 eggs should have been obtained, and produced at a low average 400 healthy chicks. The effect of acclimation was very trying to the birds, but these pioneers were not daunted. A new obstacle was, however, placed in the way of further importation. The South African ostrich farmers, it is reported, became alarmed at this large exportation. They now have, it is estimated, about $50,000,000 invested in this industry, and if they allowed large troops of birds to be freely sent to the very land that took every year one-half or more of their feathers, this immense industry would be crippled. So we are not surprised to learn that the Cape Town government, in November, 1884, imposed a duty of $500 on each bird taken out of the country. But that did not discourage American enterprise. Dr. Sketchly says:

I was so well pleased with the enterprise that last year (1886) I went to South Africa to purchase a lot of picked breeding birds and returned with them in April. I landed with 33 birds, which are now doing well.

OSTRICHES AN ATTRACTION—MORE FARMS.

Ostrich raising in California now found a new field and received a new impetus. They became a great curiosity to the many visitors that flocked to the coast, and were used to "boom" rival points. They are certainly "a sight" worth seeing.

In July, 1886, parties leased Washington Gardens, Los Angeles, and Mr. Cawston started at once to Africa and selected a troop of 44 birds. He brought them in a sailing vessel, via St. Helena and Barbadoes, to Galveston. He shipped them thence via Southern Pacific Railroad, reaching his destination with about 40 fine birds. They arrived during the laying season, and a writer* (November, 1887) says:

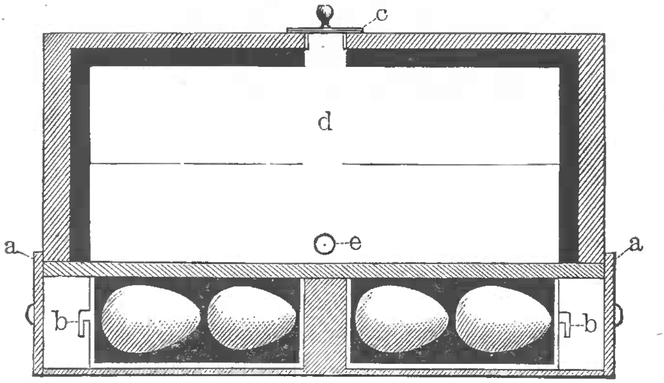
Perhaps at the present time the most attractive part of Messrs. Cawston & Fox's yards are the 9 little two-months old babies, a sight seen by few Americans and well worth going a long way to see. The writer saw them when a day or two old, and will long remember their quaint ways and looks, tumbling around like little chicks, but nearly the size of grown hens, with gray down on their backs.

These little ones were hatched by an ostrich hen, but more eggs were at work in an incubator, 27 of them in a 300-egg machine.

Mr. Cawston says in a letter to the writer that he lost 25 per cent., but was favored with particularly good weather. A friend of his who imported a troop lost about 50 per cent. These birds do not seem to bear the confinement of shipboard. There is no direct line of steam-ships from this country to South Africa, consequently all the importations have come in sailing vessels via South America, and thence to New York, New Orleans, or some Gulf port. The high export tax of $500 on each bird will practically prevent any further shipments from Cape Colony, as that will make the cost of the birds not far from $1,000 each when they reach this country, especially when we consider the losses that are apt to occur.

San Diego, not to be outdone by Los Angeles as an attraction, ob-

*E. C. Clapp, in California Cackler.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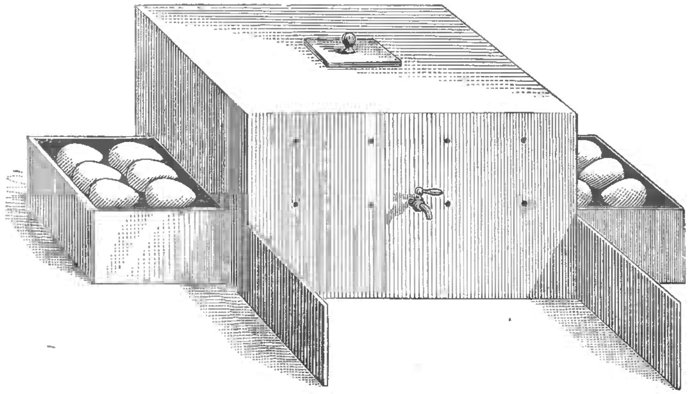
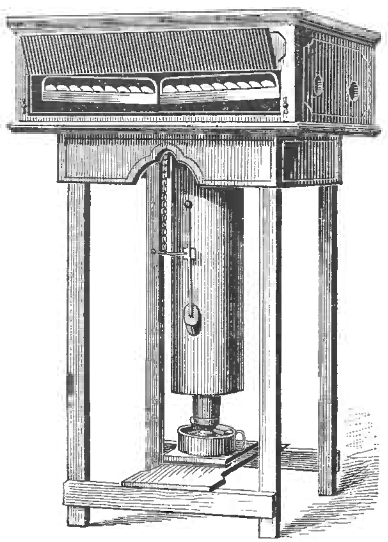




tained from the Fall Brook farm a show of ostriches for Coronado Beach. Of these a friend writes:

CORONADO BEACH, *June* 4, 1887.

DEAR SIR: There are 13 birds here on exhibition; 2 of them are birds that were imported from Africa, and the 11 others are young birds that have been raised in San Diego County from the old African birds. So you see they are the same kind of birds, only they have been raised in California. They are of all sizes, from that of a partridge up to a full-grown ostrich.

They are superior to the African chicks of the same age, as their food is better than in their native country.

Their plumes are very fine and they enjoy the best of health. The old birds have been in California over three years and are thoroughly acclimated and in good breeding condition.

They do not begin to lay till they are three years old. The oldest of our chicks are not yet two years old.

The female lays from 30 to 90 eggs in a year. The first two years it was hard to raise the young chicks, but this year we are having good success. I think it will be in time a paying business.

Yours, truly,

——— ———.

There are now six or more places where ostriches may be seen in California, and at four of them are breeding camps.

INCUBATORS AND OSTRICH EGGS.

One of the great difficulties met in this new enterprise was in obtaining reliable artificial incubators. If the old bird is allowed to sit she will stop laying when about 16 eggs are deposited in the hollow nest they scoop out for a resting-place for the eggs. Then these birds are very sensitive and take fright and offense very easily, and if the eggs are handled even, or the nest but slightly disturbed, she will forsake the nest. Sometimes they will leave it when the chicks are nearly ready to break through the shell. The risk in getting chicks hatched is quite as great, especially with young birds, as it has proved with the incubators. Various experiments were made and many eggs spoiled before an incubator was found that was at all reliable.

The Petaluma incubator (see cut) has practically a monopoly of the ostrich-hatching business in California. Eight different styles of machines have been tried at the several ostrich farms, and the Petaluma has proved to be the most successful. Three of these machines are in use at the farm of the American Ostrich Company, one at the farm 6 miles from Los Angeles, and one is now being built for the Washington Gardens Ostrich Farm, Los Angeles. The following letter speaks for itself:

MOUNT FAIRVIEW, SAN DIEGO COUNTY, *April* 14, 1887.

PETALUMA INCUBATOR COMPANY:

DEAR SIRS: Your favor of the 8th to hand, and in reply will say that so far we have hatched 80 per cent. of all fertile eggs; the balance would not have hatched under any circumstances, the condition of the birds not being favorable for thoroughly good eggs. We have lost a good many from malaria, but this is in no way attributed to the machines. I believe every good egg placed in the Petaluma will hatch out a good, strong chick. We now have at the beginning of this season 43 as fine young ostriches as ever were hatched. I can not suggest any improvement for hatching ostrich eggs, nor do I believe that the Petaluma can be improved materially. The first machine I had of you two years ago is as good as the day I received it, and it has been at work constantly upon fowls' eggs, of which Mr. Campbell, our foreman, hatched out 100 per cent. when there were no ostrich eggs for it. The other two machines are also in good trim.

Yours, truly,

E. J. JOHNSON,
Manager American Ostrich Company.

Mr. Johnson writes (June 20):

We have just hatched 15 chicks from a clutch of 17 eggs, 88¼ per cent. This is very good, and has seldom been surpassed in Africa.

With this fair beginning we learn that the result was not so satisfactory. Mr. Johnson writes us (February 24, 1888):

We raised only 20 birds last year; a small proportion of eggs laid and chicks hatched.

The young ostrich is very liable to colds, and many succumb before they are a month old. Possibly the cool nights of California have something to do with this large mortality.

As an example of what has been done by artificial hatching, Mr. Douglas* cites the following:

One set of 3 birds, a cock and 2 hens, during the period from June 30, 1872, to June 30, 1873, laid 188 eggs, from which was hatched by incubators 133 chicks. Of these 18 died, leaving 115 young birds. Of these he sold 74 at 3 months for £16 each ($77.44), and counting the remaining 41 birds worth only £12, there is a return of £1,676 or $8,111.84. The next year the same set laid 113 eggs, producing 77 chicks, and the first six months of the third year they laid 97 eggs, producing 81 chicks, being over 80 per cent. After this the cock was killed by a rascal for his feathers.

One of the illustrations is from a photograph of the first ostriches which were hatched here after I came, and which are now more than a year old; the other is of chicks two weeks old, two ostrich eggs with a hen's egg beside them, and my dog Floss.

The incubator used was the Douglas, but an extensive ostrich dealer says that Christy's is considered by most of the ostrich raisers in South Africa as the best of the incubators. (See cut.)

On the raising of ostriches in California a friend gives his observations as follows:

We use the Petaluma incubator. It is the best one made. The chicks are from three to six days old before they eat anything. The first thing they eat is sand and fine bone, the last named we break up for them. After that we feed beet and cabbage leaves cut very fine.

If they have a chance to run where grass is growing they can get their own living. If the chicks are healthy they will eat about all the time. We put them out in the morning as soon as it is warm enough; at night we put them in an old incubator we keep for that purpose only.

They do not bear the cold well until they are about six weeks old; after that they are quite hardy.

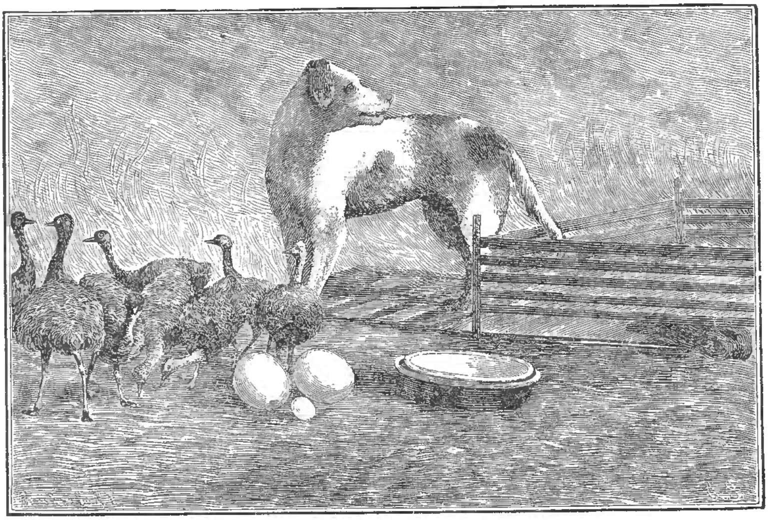
We have a book on ostrich farming (Douglas), but you can not learn much from it. It takes experience and constant study to make a success of the business.

The Los Angeles farm is the largest, but the San Diego one has raised more chicks, and better ones also.

I do not know whether the ostrich would thrive in Texas or the South. They are natives of a very warm and dry climate. The young chick can not stand rain or heavy wind.

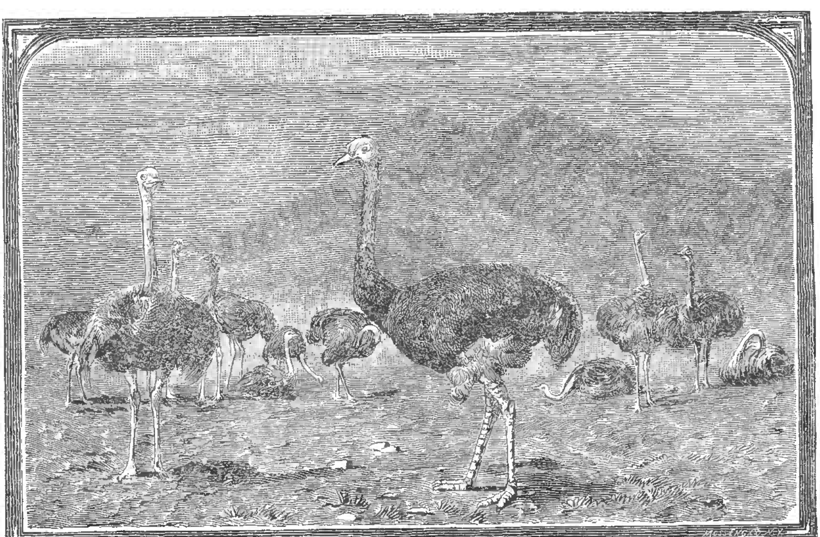
The ostrich lays an egg every third day. The eggs are large, being 5 to 6 inches through the long diameter, and weigh from 3 to 5 pounds each. The shell is usually very thick, sometimes one-sixteenth of an inch. The contents resemble that of a hen's egg, and, as Dr. Barnes's letter informs us, amount to 40 fluid ounces. The period of incubation is variously given at from thirty-eight to forty-two days, and doubtless depends upon the vitality and development of the chick. The average in California is thirty-nine days. The young chick can be heard in its shell days before it appears. It is sometimes necessary to assist the chick in breaking the shell. In

* Ostrich Farming in South Africa, p. 217.



OSTRICH CHICKS TWO WEEKS OLD. THE KEEPER'S DOG. TWO OSTRICH EGGS COMPARED WITH A HEN'S EGG.

From a photograph.



A TROOP OF CALIFORNIA OSTRICHES "MORE THAN A YEAR OLD."

From a photograph.

the wilds of Africa the crows have learned to crush the ostrich eggs by letting stones fall on them from a height. In Africa the empty shells are used to carry water; a net-work of grass is made so that several may be carried at once. In California there is a ready sale for the empty shell, in some instances as high as $5 being paid for them as a curiosity.

A GLIMPSE OF OSTRICH FARMING IN AFRICA.

It may be interesting in this connection to see ostrich farming in South Africa through the eyes of Mr. Leyland,* F. R. G. S., who writes:

FRIDAY, *October* 22, 1880.

Accompanied by a friend, I drove this afternoon to Craddock Place, a large ostrich and sheep farm belonging to Mr. Bennett, about 5 miles out of Port Elizabeth. He farms 5,000 acres. Of this area 2,000 acres are in the bush, and are laid out in "breeding camps," or divisions of from 5 to 10 acres each. In each camp a pair of birds—a male and female—is placed. They are daily fed with some grain, salt, and crushed bones, in addition to what the camp ground provides for them. Mr. Bennett showed us the Douglas patent lamp incubator, then that of Messrs. Christy & Co. (See cut.) The hot water in this is supplied from an adjacent boiler every few hours, the incubator not having a lamp, as in Douglas's. It was very interesting to see the various drawers pulled out as from a chest, disclosing rows of ostrich eggs. Some of them were just about to break and the young birds to make their appearance. Mr. Bennett said he preferred to sell these birds when three days old for £5 ($25) apiece, rather than keep them for three months, when he could obtain £10 each. The stories told of "money made" through the instrumentality of these birds are something fabulous. For instance, a pair of good breeding birds is worth from £150 ($750) to £200 ($1,000). The number of eggs produced varies considerably, but each female bird may reasonably be expected to lay from 40 to 50 eggs in the year. There are some birds, I am positively told, bring to their fortunate possessors at least £400 to £500 per annum, through the number of eggs they produce and by the sale of their feathers. Of course, birds of this breed would be vastly more expensive to buy. The feathers are annually worth from £10 ($50) to £15 ($75) per bird. As a result of various conversations with those interested in ostrich farming I annex the following notes:

The farming of ostriches seems likely to make more radical changes in the pastoral and commercial features of the country than any other discovery or innovation that has been made since the cape was first discovered, with the exception of the opening up of the diamond fields in 1867. An ostrich farmer usually lays out his camp to accommodate a certain number of pairs of breeding birds, giving to each pair an inclosure varying from 1 to 10 acres, according to the veldt on the farm and the length of his purse. As a fact of general experience it may be stated that the larger the camps are the better will be the success, both with breeding and young birds, although many instances can be given of successful ostrich rearing on small garden plots or yards. The feathers from breeding birds are generally more or less spoiled during the time of setting, but £10 per pair may be calculated as the usual return. Breeding birds will always require artificial feeding to some extent, more grain, etc., being required during times of drought than when reasonable rains cause a luxuriant growth of the plants and bushes in the camps. It may, however, be safely estimated that £15 per pair will cover the cost of feeding if the farm does not produce its own grain, etc., in which case, of course, the amount will be proportionately smaller. One plucking of feathers per annum is all that can be expected, and the value of the produce will entirely depend upon its quality and the state of the market.

As regards the cost of the camps, if those devoted to breeding purposes are 200 yards square, and the young birds' camp is 5 miles around, there will be about 8½ miles of fencing to construct, which, if properly made with poles, wire, and bush, will cost £40 to £60 per mile. In addition to this a good incubator is an absolute necessity, which, with means for watering the birds, plucking-house, etc., may be put down at £100.

After a rapid run for some distance along a main road we branched off to a farm in the occupation of Mr. Wynand Louw. This gentleman had several pairs of

*A Holiday in South Africa.

ostriches, which he took us to see. They were inclosed in paddocks about 30 yards square, and in each inclosure were a male and female bird. These birds have a wonderful digestion. They are supposed to feed upon mealies and what they can pick up from the grass and earth in the inclosures. In one or two of the inclosures we saw on the surface of the ground nests of eggs, which the birds were hatching. Apparently "it was nice to be the father," for the male bird was doing the setting, as Mr. Louw informed us, for sixteen hours out of the twenty-four, the hen bird doing duty during the remaining eight hours.

ESTIMATED EXPENSES, PROFITS, AND INCREASE—CAPITAL INVESTMENT FOR AN OSTRICH FARM.

10 pairs of breeding birds, at £150 per pair	£1,500
100 young birds, twelve to eighteen months old, at £20 a piece	200
10 breeding camps, 200 yards square, 1 young birds' camp 5 miles round, equal to 8½ miles, at £50	425
Incubator, plucking-house, etc	100
Total	2,225

ANNUAL REVENUE.

10 pairs breeding birds—200 chicks at £5 each	£1,000
Feathers from same, 10 pairs at £10	100
100 young birds, feathers at £6 each	600
Increased value of 100 young birds at £7 10*s*	750
Total	2,450

ANNUAL EXPENDITURE.

Feeding	£150
Rent of farm	250
Superintendence	150
Contingencies	200
Total	750

Deduct this annual expenditure of £750 from the estimated annual revenue, and it leaves a net return of £1,700, or 42½ per cent. on the capital investment.

Another large source of revenue may also be mentioned, namely, the rearing of chickens instead of selling them as hatched for £5 each; but as a proportionately great risk is run, the estimate given above is the most reliable. The risk of loss, however, during the first few weeks of their existence is very great, and much experience and care are required for success in this branch of the industry, as well as an ample supply of green food of particular kinds, which can not always be grown on account of want of water or unsuitable soil.

What return do birds give on the capital invested? This would be the first question asked by any one thinking of going in for farming. It is a question very few, even of those that have been at it some years, could answer, and of which the public have the most wild ideas, or else the promoter of the joint-stock companies that have been lately started in all directions would never have the barefacedness to advertise prospectuses promising the public from 40 to 100 per cent. per annum on their investment, including in this even the capital sunk in land, building dams, etc., which give no direct return, and which in England would represent the landlord's investment, and which is subject to scarcely any risk, the fencing, building, wagons, etc., being the only part subject to natural decay. A return on the whole of this part of the capital of 15 per cent. per annum would be a good return.—DOUGLAS.

The ostrich industry began in Cape Colony in 1865 with 85 birds, but when a decade had rolled around the number had increased to 22,247 ostriches. Then the industry began to attract general attention. The demand for birds for farming purposes was so great, especially for the next few years, that fabulous prices were realized by those who had birds to sell.

The increase in Africa is estimated at about 20 chicks each year to a pair of breeders. So we can see that the increase is at a rapid rate, although the proportion of pairs of breeders to young birds is very small. Allowing them to double every five years there are now, it is estimated, upwards of 100,000 ostriches in South Africa.

Having taken this hurried glance at this new and profitable industry, a careful study of the ostrich will be next in order.

THE OSTRICH FAMILY.

The ostrich is a noble bird of giant form. It stands about 8 feet high when full-grown, and in the wild state defies the horse and rider. Its rich plumage has been adopted as a part of court dress.

The ostrich family is represented by four species, viz, the Ostrich proper (*Struthio camelus*), the Rhea, the Emu, and Cassowary. Some naturalists give a fifth, viz, the Apteryx, inhabiting New Zealand; but this we consider a mistake, as, although it possesses many of the characteristics of the ostrich, it differs from them so much in other respects as to exclude it from the family. The family differs from other birds in having only rudimentary wings, unadapted to flight; in having the barbs of the feathers of equal length on each side of the quill, and of such a nature as to deprive it of the means of flight, and in having the breast rounded like a barrel, instead of being like a keel, as in birds of flight. The ostrich proper is distinguished from the other members of the family by being the only one with two toes; by being twice the size of the others; by its eggs averaging upwards of 3 pounds in weight, whilst the others barely average 1¼ pounds; by the head and neck being bare of feathers; by the beauty of its plumage, the only other member of the family producing feathers of any marketable value being the rhea.

It is indigenous to the whole continent of Africa and is also found in Arabia, but in the latter it is now nearly extinct. The rhea, or South American ostrich, has three toes and no tail, and produces feathers somewhat similar to the chicken feathers of the ostrich proper. They are known in the trade as "vantour" or vulture feathers, being worth from 4*s.* to 30*s.* a pound. A curious case of swindling came to light last year in Port Elizabeth, where a man largely engaged in the feather trade imported large quantities of these feathers and, mixing them up with the inferior kinds of white and gray ostrich feathers, sold them again as ostrich feathers at an enormous profit, completely deceiving the colonial buyers, the matter not being discovered till the feathers got into the hands of the London manufacturers.

The rhea inhabits, in vast numbers, that part of South America which lies south of the equator and east of the Andes Mountains, extending down to the Straits of Magellan, thus reaching to 18 degrees nearer the pole than the ostrich. It is being rapidly destroyed for the sake of its feathers, which are being exported in enormous quantities, principally to North America and France. The egg of the rhea, like the ostrich, is cream-colored when fresh laid, gradually turning quite white.

The emu inhabits the whole of Australia, and Australia only. It has three toes, is of a brown color, the feathers being of a crisp, hairy nature, and of no commercial value. Its eggs are very handsome, being of a deep-blue color, and much indented. It has all the habits of the ostrich. The plumage of the two sexes is of the same color. It is fast being destroyed as the country gets filled up with sheep.

The cassowary is found sparsely in Northern Australia, some parts of the Malay Archipelago, and in the South Pacific. It is distinguished from the other members of the ostrich family by a large horny excrescence on its head, and most of the species, of which there are several, have one or two wattles suspended from the neck. It stands, like the emu, about 5 feet high, is of a very dark-brown color, has hairy feathers of no value, is quite wingless, and lays a light greenish egg.

The whole tribe are known for their excessive shyness and timidity, without which, in the struggle for existence in the world, they would ere this have ceased to exist, from being deprived of the powers of flight. We have taken this glance at the other members of the family, as it is essential that the ostrich farmer should know thus much of them.

PECULIAR ANATOMY OF THE STRUTHIO CAMELUS.

We will now glance at the anatomy of the ostrich.

The leg.—Most people call the joints by their wrong names. The ostrich walks on its toes; what is commonly called the ankle joint is the second toe joint of man.

The so-called knee joint corresponds with the ankle joint, and the so-called thigh, where we brand, with the calf; the proper thigh being the short thick bone above this. This is the usual formation of all swift-footed animals, the part from what most farmers call the knee downwards being the foot, the heel being exceedingly long. It is very advisable that farmers should remember this, so that in describing to each other malformations or injuries there should be no confusion; so we have, first, the first toe joint; second, the second toe joint; third, the ankle joint; fourth, the knee joint, above the place we brand; fifth, the thigh joint. The leg is easily broken, either with a blow or when they are dancing, when there is nothing for it but to kill them. They are also subject to spraining the ankle joint and instep, for which the best remedy is cold-water bathing and arnica lotion. We have had them put the ankle joint completely out; if seen to at once this can be easily pulled in, and a few hours' cold bathing and leaving them in a dark stable, so that they do not use the leg, will put them all right in a couple of days. They will sometimes get tumors on the leg; these are easily opened and removed, then the place should be well cauterized. Young birds will sometimes get a staggering gait, knocking the legs together as they walk; this is the after-effect of the birds having eaten some poison, and although they may live for a long time they will gradually get worse and die.

The wing, which constitutes nearly the whole value of the bird, is exceedingly small, and the feathers are unadapted for flight, but in other respects it is perfect. They are rather subject, especially as young birds, to put out the first or small joint, which is known by the wing hanging down. It is easily pulled into place, and should be at once tied to the other wing over the back and left, when it will soon get right again.

The head is exceedingly small, and consequently the brain is small also. This has been calculated to be in the proportion of 1 to 1,200, as compared with its whole body, whilst the eagle's is as 1 to 160, and the parroquet's as 1 to 45; and yet the bird is anything but stupid, as every man must own who has seen it breaking open the shell to let out a chick that is fast inside, or has seen it managing its chicks.

The eye is the only organ of the head usually subject to disease. In all cases there is nothing like pouring in a lotion of sulphate of zinc, and repeating it constantly, as much as will lie on a shilling to a quart bottle of water is the strength required. Ants have been known to attack little chickens and nearly blind a whole brood, which were all saved with this treatment.

The neck is remarkable for its great length and for its formation, allowing the bird to turn its head completely around. They are very apt to get bones stuck fast in swallowing; if they can not be forced up again an incision should be made, the bone removed, and the place sewed up, when it will quickly heal.

The heart lies immediately under the junction of the neck with the body. They are very subject to dropsy of this organ, or what is commonly known as water on the heart, which will be treated of when considering worms.

The lungs lie along the backbone, extending down the ribs, but not adhering to them. They should be of a beautiful vermilion color. When diseased or congested it will be known by their black appearance, and by the clotted blood found inside.

The liver comes immediately behind the heart. "There is no gall bladder." In health it is of a deep plum color, with a beautiful flush on it, and is remarkable for its inviting look. These constitute the organs protected by the ribs, and are separated from the remaining organs by the diaphragm across the body.

The gizzard.—Continuing our course from head to tail, we next have the gizzard, or the mill where the food is ground up. This should always be hard and full of stones. It is subject in disease to get flabby, and consequently to allow the stones to pass into the intestines and out in the dung, as they should never do if the bird is in health.

The stomach is the organ into which the food passes at once when swallowed. It corresponds with the crop of other birds. It is here that the juices are given out to the food from small cells dotted over a portion of the stomach, and it is the seat of one of the most formidable diseases that have yet appeared (see Worms). From the stomach the food passes up into the gizzard, and from thence into the intestines. The stomach and the gizzard are united together, and held by a diaphragm to the left side of the bird, to the left side of the backbone, and to the diaphragm, which divides the body in two. Thus the right side of the body, when the stomach is empty, has in it only the first small entrail; when the stomach is full it extends nearly from side to side. These are points to be borne in mind when considering caponising.

The intestines.—These are roughly divided into the small and large intestines, or otherwise the upper and lower. The small intestines extend from the gizzard to the "cœca" (otherwise known as the two blind stomachs from their having no outlet). In the small intestines the food is converted into what is called chyle. It is

here we find the tape-worm. From the "cæca" the large intestines begin. First, we have the maniply, or what corresponds in cattle and sheep to the book paunch. From the maniply we pass on down the large intestines to the rectum. It is in the latter that we get constipation, or stop sickness, which is so fatal to the Ostrich.

The testicles of the male or the ovarium of the female lie opposite the stomach, and under the hump in the backbone, to which they are suspended.

The kidneys are exceedingly large, extending along the backbone from the testicles to the bladder.

The bladder lies just below the rectum, and is nothing more than an enlargement of the extreme end of the intestines. (The ostrich is the only bird that urinates.) The penis is curled up in the bladder.

The bones of the ostrich, as in other birds, are hollow. The age to which an ostrich can live is unknown. It has been usually supposed to be very great, possibly a hundred years, as some people assert, though we believe this to be guess-work. The usual calculation for animals, that of six times the period it takes to arrive at maturity, would give it twenty-four years, but we are inclined to think that it reaches a greater age than this.—DOUGLAS.

The age to which ostriches will attain is a matter of considerable conjecture. One writer estimates that some of the ostriches may reach the advanced age of one hundred years, but that is something like the estimates of profits, very unreliable. Dr. Sketchly is reported as giving an instance where a pair of ostriches had produced eggs from which as high as 50 chicks had been hatched each year for years. They were then about twenty years old. The usual growth of feathers, where these birds are plucked annually, as well as the large number of eggs produced where the bird does not set, must affect the vitality of the old birds as well as that of their future progeny. Possibly a cross with the American rhea might improve the vitality and fertility of the ostrich, but the effect on the plumage might be serious. Here is a field worthy of the attention of the ostrich farmer. Inbreeding must of necessity tend to make them liable to disease.

DISEASES AND DEFECTS.

That ostriches,* like other animals, should have their diseases, is only what might be expected; the treatment of these, however, is but imperfectly understood. In the majority of cases which have terminated fatally death appears to have resulted from disease of the lungs, the cause of which has not been satisfactorily ascertained. (Cold, damp, ill-ventilated pens perhaps.) Parasites, both external and internal, exist; of the former class two species, both suctorial, have been detected; but although they produce the usual discomfort and irritation they do not, so far as has been observed, cause any direct injury to the feathers. Apparantly no application of "insect powder" avails, but a little bran mixed with the food has been found beneficial, as promoting a healthy condition of skin. Of the internal parasites an intestinal worm, known as the "wire-worm," from its form and hardness, is the most troublesome, and the only one, it would seem, that proves fatal. The antidote is castor oil. A singular defect in the feathers, well known to those who have kept hawks, and called by them "hunger traces," is observable also in the ostrich, but only in tame birds. It appears as a line of imperfection across the web of each feather, chiefly in those of the wings; while on the shaft the mark may be not only seen but felt as a slightly projecting ridge. The injury from this cause is sometimes such as to occasion the feathers to break off at the "hunger traces," and it is not improbable that the mark seen on the web is in fact owing to the breaking off of all the fine fibers of the web in the line of the trace.

Ostrich feathers thus marked are said to be "bitten," a term which, like the French equivalent, "coup de bec," conveys the erroneous idea that the injury is caused by the bird's own beak or by that of its companions. Now, it is well known to falconers that in hawks this defect arises from the want of proper and sufficient food (hence the term "hunger trace") at some period during the growth of its feathers; and there can be little doubt that this is so in the case of the ostrich. It occurs most frequently in time of drought, when the birds are unable to procure their natural

*Harting on Ostriches.

diet and have to be fed on maize or such other dry food as is most easily obtainable. This produces an unhealthy condition of skin, and experience has shown that the remedy lies in the cultivation of Prickly Comfrey, which not only withstands drought well, but furnishes the birds with excellent food, well suited to their requirements.

These birds with "barred" and coarse feathers, with distorted quills, are palmed off on the unitiated. An ostrich dealer in Africa informs the writer that such birds are discarded by experts, but he fears that some of them may find their way to America; in fact have been purchased for the export trade.

It is simply a matter of impossibility for an inexperienced man to select either birds or feathers, and any one in the ostrich-feather trade will corroborate this statement.

Further, one should be very careful not to introduce that fatal disease, tape-worm, into an ostrich camp. If one bird contracts the disease the others are soon in the same condition; this they acquire by swallowing the excrement of the infected bird. The mortality is very rapid when it once sets in.

WHAT OSTRICHES EAT.

Ostriches are not expensive to keep [says Mosenthal], for during the greater portion of the year they can find enough to live upon in their inclosures, and at other times only require a little Indian corn or beans, and some additional green food in the shape of lucerne, all which can be grown on the farm.

In Algeria Captain Crêpu found that the birds throve well on barley, fresh grass, cabbage, and the leaves of the cactus or Barbary leaves chopped fine. He recommends about 3 pounds avoirdupois of barley a day for each bird, and green food according to circumstances. In winter and during the breeding season a more plentiful supply than usual should be given. Mr. Kinnear states that for their usual food nothing equals lucerne or trefoil, but they also like cabbage leaves, fruit, and grain. Maize, or Indian corn, better known as "mealies," they are very fond of. As is the case with cattle, the nature of the soil and the climate must be carefully studied if ostrich farming is to be carried on successfully. The birds will, of course, live and to a certain extent thrive on grass or sour veldt, but they do much better on the "karoo." Here they find and take into their system the natural alkalies which are so beneficial to their health, as well as the fruit and berries of various wild shrubs and plants, which, with grass and leaves, form their chief food when in a wild state. Under these conditions the birds grow well and become strong, and the feathers get finer, heavier, and more valuable.

In California the food is chiefly grass, grain, vegetables, weeds, and plenty of broken bones and gravel.

AGES, DISTINGUISHING FEATURES, AND MANAGEMENT.

Ostriches [says Douglas] are generally designated as chicks up to seven or eight months old, or as long as they have still got their first crop of feathers on. From then till they are a year old they are called feather or plucking birds.

The next two years they are properly designated as four and five year old birds; but in advertisements of sales and prospectuses of companies they are often called breeding birds, but this is only a trick to swell the appearance of the thing.

We have heard of cases of men buying birds as breeding birds thinking they were laying birds that had already bred, and finding afterwards that they were only four or five year old birds that had not yet bred, and were consequently only worth about half what they gave. Birds that have been paired off in separate camps, but have not yet bred, are often called "camped-off birds." As they may be camped off at any age the term conveys very little information, though four years old is the usual age for camping them off. After they have bred they become "guarantied breeders," and have changed their designation for the last time.

The distinguishing marks of the different ages are somewhat as follows, though it must be borne in mind that a very forward bird of one age will have many of the marks of the age above him, while a backward bird will have many of the marks of the age below:

Six and a half months old.—The quill feathers will be ready to cut; some of the body feathers will have begun to change; some of the cocks should begin to show black feathers; all cocks should show white on legs and bill.

Twelve months old.—The second growth of quill feathers should be showing; some of the cocks should begin to show black feathers; all cocks should show white in legs and bill.

Two years old.—All the chicken feathers should have gone from the back, and the cocks should show quite black or nearly so. Most of the little white belly feathers should have been replaced by blacks or drabs, according to sex.

Three years old.—There should not be a single chicken feather to be found on the body; the last place from which they disappear is where the neck joins the body. Every vestige of the white belly feathers has gone. The bird's plumage has reached perfection; some of the cocks will be red in front of the leg and on the bill.

Four years old.—The birds have reached maturity. The breeding organs are fully developed; the cocks in season will have the back sinews of the leg pink, the front of the leg and the bill scarlet, and much of the fineness of the feet, the leg, and the lines of the body will have gone.

Five years old and upwards.—The only distinguishing marks we know are a generally coarser look of the limbs and body, and an increasing coarseness of the scaling in front of the legs and feet. Up to twelve months old the birds should be treated as chicks, being herded and fed with 1 pound each of either wheat, barley, or Kaffir corn, shedded in wet weather, and green food cut up for them when the grass is dry. After this age they can be put in a large camp, of not less than 10 acres to a bird, of ordinary South African veldt, and left to shift for themselves; but an opportunity should be selected for doing this when the veldt is in prime order, and even then they will be very apt to take to hanging up and down the fence nearest the homestead; and will require to be partially herded for a time in the camp. For the next two years they will require watching, and, if the veldt should get dry, to be fed; each year as they get older they will get more robust, and better able to stand hardship and scarcity of food. Up to three years old they will often suffer terribly from internal parasites, and occasionally, especially if food is scarce, require to be physicked (see Diseases, etc.). If the fences are good, once a fortnight is quite often enough to muster them.

Every farmer should keep a stock book, and carefully note the count in each camp. Trusting to memory is uncertain; a bird is taken out for some reason, or some are sold, or one dies, and these are very apt to be forgotten, and much trouble and uncertainty as to what the count should be is thus caused.

The days of cutting the feathers or pulling the stumps of every bird on the farm should be carefully noted in a book. If this is not done the feathers will be very apt to be left a few days too long, and be considerably damaged; or else, perhaps, in a very busy season much time will be lost by getting the birds up to pluck, and then finding that the feathers are not yet ready.

Every bird should be branded with the owner's initials in large letters of about 4 inches. The branding iron should not be more than an eighth of an inch broad on the burning edge. If many birds are to be branded there should be three irons, to insure their being red-hot. The birds should be put in the plucking box, and a few mealies thrown to them to attract their attention from the operator, when no holding will be required. The irons being red-hot, they only require to be applied and removed almost instantaneously, and then a dab of oil should be put on the place.

The mistake that is generally made is in keeping the iron on too long, thus destroying the skin and making a sore.

ROYAL PLUMES, PLUCKING, AND PROFITS.

The rich plumes of the ostrich have always been admired. For grace and beauty no plumage or ornament can compare with them.

Each bird has 25 white plumes in each wing with a row of protectors, floss feathers underneath. Above these are a row of blacks and still another row of shorter feathers which are black in the adult male and drab in the hen. The male and female birds can not be distinguished by an ordinary observer until over two years of age. A single crop of feathers is worth $250 on the ground.

The method of plucking the birds Mr. Johnson described as follows:

In Africa it is customary for two or three white men to go into the corral with a half dozen blacks and run down the birds which are ready to be plucked, which was not only a waste of time, but extremely dangerous as well, as they are terrible kickers, and the breeders especially are quite ferocious. Here the most sensible

plan is, when it is necessary to pluck a breeder, to entice it into a little pen to eat some grain, so that a stocking may be slipped over its head. This takes away its courage, when it can be plucked with safety. The feather birds are caught in the paddock while eating, and plucked in the same manner.

The birds were at first plucked every six months, but once in eight months is now the rule. The feathers are first cut off, and in about two months the stump quills are pulled out.

Dr. Sketchly wrote:

I am now (June, 1887) producing about $200 worth of feathers each per year. We find a ready sale for the feathers at $4, $5, and $6 each, for which we could not get more than $1 in Africa. They are equal to feathers sold in the stores at $10 and $15 each.

Mr. Johnson says:

Plumes have been very cheap for two years, but we expect them to be up again by the time we have enough to make it an object. We have a fine lot in New York in process of dressing. Prices are very variable, from 21*s.* to £15 per pound.

On dressed plumes there is a duty imposed of 50 per cent. of the value. The value of the exportation of feathers from Africa was, at last accounts, the enormous sum of £1,000,000 per annum; of this amount it is estimated that America absorbs $3,000,000 at least.

The New York importers have long enjoyed a monopoly in this business, and many large fortunes have been made by them.

The North Africa or Barbary feathers are superior to those of South Africa, and command a higher price in the market. If the American feathers should prove superior it will create a furor in the feather market. From North Africa there is a large exportation of feathers annually, amounting to about £500,000.

The Barbary feathers are shipped chiefly from Tripoli through Marseilles to Paris or London. The feathers before shipment are "roped" for the market; that is, they are sorted into grades, prime whites, first whites, second whites, tipped whites, best fancy colored, and second fancy colored The choicest are picked out and sold privately. A California lady said that the finest plumes she ever saw were worn by ladies interested in the ostrich farms. The South African plume is characterized by its breadth of barb, and each individual barb has a richer floss, but the barbs not being set so close as those of the North African birds, the plume has a thinner appearance. The shaft, though full as long, is straighter and less graceful than a Barbary plume, but it has a compensatory advantage in bleaching to a far purer white. (Bigger.)

The great point of natural beauty in a feather, in addition to its richness of plumage, is the graceful curve taken towards the tip.

To compete with the Barbary feather trade the North African birds are being imported to South Africa. When these become acclimated the Capedealers hope to export "the finest quality of feathers in the world."

It may interest the reader to know that this venture in ostrich farming in America is watched with great interest by ostrich farmers generally.

The united testimony of those competent to judge is that the American birds are larger and finer than their African progenitors.

Mr. Johnson writes:

Compared with the African progeny, our California chicks are superior to most that I saw in Africa. They are larger, more vigorous, and of better plumage, owing doubtless to better care. We expect our troop to increase rapidly when our California birds are old enough to breed, but not before.

Dr. Sketchly writes:

We have now (June 3, 1887) a number of young birds of all ages, from two days to seven months, hatched here. The seven months birds are much larger and finer than any birds I have seen in Africa of the same age.

This climate is very similar to that of South Africa, and the constant supply of green food afforded all the year will make this vicinity one of the most important in California in the near future.

This industry is yet in its infancy, but it will soon become a most important one. In Africa ostrich farming is only twenty years old, and it is the third in importance at the present time in that country.

The diamond mines and sheep farming have outranked it, but it is estimated that the ostrich industry will soon take first place.

The general utility of the ostrich makes it a bird of great promise. The turkey is a Thanksgiving bird, but the ostrich might properly be a New Year or an Easter one.

OSTRICH EGGS AND MEAT AS CHOICE FOOD.

Ostriches can be utilized as food, and may come to rank high as an article of diet when so numerous as to be profitable in that direction. The egg has been regarded as a rare delicacy in Africa.

The following report from my scientific friend will be read with interest:

SAN DIEGO, *May* 19, 1887.

DEAR DOCTOR DUNCAN: Regarding the value of the ostrich egg as food I have no information except that derived from my own observation, which has been limited.

I was invited by Mr. Johnson to a lunch, at which an omelet made of one egg was served for eight of us, and it was sufficient for all.

I could see no difference between it and that prepared with hen's eggs.

I was then presented by Mr. Johnson with one egg, the contents of which I removed, amounting to 40 fluid ounces. I divided it between two families and partook with one of them of the egg scrambled. The other family prepared it in some usual way and used a part of it for making a cake. None of us could notice any difference between it and the egg of the hen.

I confidently expected to find some distinguishing quality, but found none of that strong flavor that characterizes the egg of the duck and goose. I could find no reason for concluding that it was inferior in any respect to the egg of any other bird or fowl in respect to flavor or nutritious quality.

Yours, fraternally,

G. W. BARNES, M. D.

When an ostrich in South Africa is killed, from accident or other causes, every part of the bird is utilized. The first step is to remove the skin so as to preserve the feathers uninjured. The next is to melt the fat, which is poured into bags made of the skin of the thighs tied at the lower end.

The grease or fat of the bird in good condition will fill the skin of both legs, which hold about 4 gallons; not only is it eaten with bread and used in the preparation of "kookoosoo" and other foods, but the Arabs regard it as a useful application in certain maladies. In all cases of rheumatism or acute pains it is used by being well rubbed in, and then the affected parts are covered with heated sand.

Those who have tasted ostrich meat state that it is both wholesome and palatable, although as might be expected in the wild bird it is somewhat lean and tough. When the birds have been domesticated, however, and fed on lucerne (clover) and grain the meat becomes juicy and tender.

Notwithstanding its prohibition by the Jewish legislator, it would seem that ostrich meat was not unfrequently consumed in olden times.

Firmus, one of the kings of Egypt, it is said, used to dine off ostrich, and according to Lampridius, the Emperor Heliogabalus on the occasion of a great feast caused the brains of six hundred ostriches to be served up in one dish. It is related of Leo Africanus that he partook of ostrich meat in Numidia, where it is said young ostriches were then fattened expressly for the table.

Strabo gives a curious account of the Strutho-phagus, a black tribe on the upper Nile, who hunted and lived upon ostriches and clothed themselves with the skins of the birds.

A recent observer, Canon Tristam, has remarked that the Arabs of the present day eat ostrich meat and that he himself has tasted it and found it palatable. This opinion is shared by Hartmann (Journal für Ornithologie).

Mr. John Parkes, of Wheatland, Cape Colony, reports that in 1875 he had a troop of ostriches feeding in veldt; an antelope suddenly jumped up among them and they took to flight. While running at full speed one of the birds put his foot into a hole and broke his leg; the poor bird lay there all night and next morning Mr. Parkes brought it to the homestead in his cart. Finding it impossible to set the bone the bird was killed and the meat converted into steaks and "biltong." It was said to "eat just like young beef, juicy and tender, with just a suspicion of a sweetish flavor, usually undiscoverable in beef."*

So long as the present value of ostrich feathers is maintained it is not likely that many birds will be killed for the sake of the meat alone.

Even the skeleton of an ostrich commands a good price for public museums. Professor Ward, of Rochester, we understand, asks $125 for a full mounted ostrich skeleton.

GENERAL UTILITY OF THE OSTRICH.

Experiments have been made from time to time with a view to test the capability of the ostrich in drawing and carrying burdens. According to Montaigne, "L'Empereur Firmus fait mener son coche à des autruches de merveilleuse grandeur, de manière qu'il semblait plus voler que rouler." ("Essais" liv. iii, chap. VI.)

Dr. Sparrman, a century ago (1775), saw mounted ostriches at the Cape; and before him Moore had recorded his having seen an Englishman at Joar traveling long distances upon a bridled ostrich. (Travels in Africa.) Adanson speaks of the ease and rapidity with which a large tame ostrich ran, first with two little blacks, and then with two full grown-negroes on its back, while a smaller bird, with equal facility, carried a single full-grown man. (Voyage to Senegal.)—(HARTING.)

The late Mr. Blyth informed Mr. Harting that ostriches from North Africa are frequently offered for sale in Calcutta, and that he saw some years ago in the gardens of the Maharajah of Burdwan one mounted by a boy. In the Jardin d'Acclimatation in Paris at the present day the keeper may occasionally be seen amusing himself by driving a little car drawn by an ostrich.

When domesticated in Texas, as they doubtless soon will be, we expect to hear that the cow-boys utilize ostriches in herding cattle. Their fleetness should make them excellent mounts for scouts and couriers.

OSTRICH FARMING AT OTHER POINTS.

From the examples already given of successful acclimation out of Africa it is evident that ostrich farming can be pursued with success elsewhere than in the bird's native land. M. Mosenthal thinks that "the southern provinces of Russia, Spain, Italy, New South Wales, and some parts of South America and of the Southern United States offer to a great extent many of the conditions which experience has shown to be requisite for breeding and successfully domesticating this giant bird."

Ostrich raising has taken a firm hold of South America.

With the first importation to the United States came a troop of nearly 200 birds that were landed at Buenos Ayres, and we learn that the industry is now growing rapidly.

The rhea flourished in that section even as far south as Patagonia, and doubtless the *Struthio camelus* will prove equally as prolific when it once becomes fully acclimated.

The pampas of South America, like the plains of Texas and New Mexico, so closely resemble the "Karoo" of South Africa that ostriches should do as well there as on their native heaths.

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*Mosenthal & Harting, Ostriches and Ostrich Farming, p. 52.

Mr. Johnson says:

From my knowledge of ostriches and their needs I believe that in Arizona, New Mexico, Texas, and Georgia favorable localities can be found for them, and that a great part of old Mexico is especially suitable.

Whether ostrich farming will succeed in other parts of America time and experiment alone will tell. The ostrich is a tropical bird, but will endure a great deal of cold. An emu imported to England seemed none the worse for the change; but the habit of these south-equatorial birds to begin to lay in the winter months subjects the chicks to too rigorous weather. Possibly when they become acclimated so that they will lay and hatch in the hot months they may be found to flourish even in the more northern States. Texas and the Southwest would seem an inviting field, but even there the birds should be protected both from the cold northers and the winds.

INVITATIONS FROM MEXICO AND GUATEMALA.

There has recently been organized in California a company with $1,000,000 capital, called the Central America and Guatemala Ostrich Company, to push this industry in a new field. The Government of Mexico has offered them a grant or concession of 32,000 acres of land, besides a subsidy or bonus of $200 for each bird three years old, up to the number of two hundred. I am informed that the Government of Guatemala has been equally generous towards this industry. Those countries, it is believed, are especially adapted to the raising of ostriches.

The chief obstacle in the management of these birds in California is the large expense for land rent and help. An ostrich farmer, Mr. Burkett, writes:

As regards profits, if you get land cheap and labor cheap there is no more expense than in keeping fowls, and the profits would be enormous; but we pay $40 per acre per year for the land, and $40 per month and board to a man. Of course that is a great item.

With such a large grant of land free, and labor cheap, as it is in Mexico and Central America, this company starts out well, and should make a profitable business of it.

PRESENT PRICES OF OSTRICHES.

Mr. Berkeley, a Cape Town dealer, writes (February, 1888):

As to prices, they vary from £10 to £30 per bird, according to quality, age,* etc., the proved breeding birds of course being the most expensive. If you import any chickens I would not advise you to ship them too young, as they need great care. I should recommend a few pairs of breeding birds and a few birds over and above a year old, say up to two years. The boxes for them should be nicely padded, as chafing often causes death.

Notwithstanding the low prices quoted, Mr. Burkett, who imported a number recently, says:

It is very risky and very expensive bringing them from Africa. Mine cost me as near as possible $500 per bird; then I had several that died. I believe that you can buy them very cheap here.

It may interest some parties to know that an African ostrich dealer offered to buy choice proved breeders and accompany the birds, provided his expenses were paid by steamer and back to Natal, with a

* He must refer to young birds.—J. C. D.

remuneration of say £16 a month. I presume that arrangements could be made with exporters to deliver birds in America for a fixed price.

It will be seen that the price of birds is now much lower in Africa than a few years ago. From the fine crop of birds in California a selection could doubtless be made for any new farms that might be started. A troop of twenty full-grown birds, breeders, was offered the writer at the uniform price of $350 each. This was below cost, but the party was anxious to return to England. Choice birds, like choice imported stock, command good prices. The owner of a prolific pair in Africa refused repeatedly £1,000 for them.

Mr. Johnson says:

I can furnish two-year-old birds at $500 each, six months birds at $200 each and eggs at $25 each.

Dr. Sketchly says:

We do not propose to sell any chicks at present, but could dispose of a few pairs of breeders at from $1,000 to $2,000 per pair.

There is, as we have seen, certainly great risk in this business, and it would seem that it is one that the Government should encourage.

NOTE.—Since the above was written we learn that other farms are organizing. Ostrich raising is an industry of promise, and is destined to receive private if not State or national encouragement. The limits of this article necessitate the omission of much interesting information collected by the writer.

INDEX.

A.

B.

C.

D.

E.

F.

G.

H.

I.

P.

Q.

R.

S.